THE

Railway Signal Dictionary

AN ILLUSTRATED VOCABULARY OF TERMS WHICH DESIGNATE AMERICAN RAILWAY SIGNALS, THEIR PARTS, ATTACHMENTS AND DETAILS OF CONSTRUCTION, WITH DESCRIPTIONS OF METHODS OF OPERATION AND SOME ILLUSTRATIONS OF BRITISH SIGNALS AND PRACTICE

FIRST EDITION

COMPILED 1908 FOR

THE RAILWAY SIGNAL ASSOCIATION

By

BRAMAN B. ADAMS AND RODNEY HITT
Associate Editors of the Railroad Gazette

UNDER THE SUPERVISION OF THE FOLLOWING COMMITTEE:

C. C. ANTHONY, *Assistant Signal Engineer, Pennsylvania Railroad*
AZEL AMES, JR., *Signal Engineer, Electric Zone, New York Central & Hudson River Railroad*
J. C. MOCK, *Electrical Engineer, Detroit River Tunnel Company*

SECOND EDITION

REVISED 1911 BY

A. D. CLOUD, *Editor of The Signal Engineer*, and H. H. SIMMONS, *Associate Editor of the Railway Age Gazette*

UNDER THE SUPERVISION OF THE FOLLOWING COMMITTEE:

J. C. MOCK, *Electrical Engineer, Detroit River Tunnel Company*
C. C. ANTHONY, *Assistant Signal Engineer, Pennsylvania Railroad*
F. P. PATENALL, *Signal Engineer, Baltimore & Ohio Railroad*

1911
RAILWAY AGE GAZETTE
NEW YORK: 83 Fulton Street CHICAGO: Plymouth Building

THE SIGNAL ENGINEER
CHICAGO: Plymouth Building NEW YORK: 83 Fulton Street

THE RAILWAY GAZETTE
LONDON: Queen Anne's Chambers, Westminster, S. W.

RESOLUTION

Adopted by the Executive Committee of the Railway Signal Association, January 8, 1907, and approved by the Association at its annual meeting in Milwaukee, Wis., October 10, 1907:

"WHEREAS, The Railroad Gazette has proposed to publish under the direction of the Association, an illustrated dictionary of railroad signals and signaling; therefore be it

"Resolved, That the Railroad Gazette be, and hereby is, authorized and empowered under the supervision of a committee of this Association to publish an illustrated dictionary of railroad signals and signaling."

The Executive Committee appointed as the supervising committee the members of the Association's Committee on Definitions, namely: Charles C. Anthony, Assistant Signal Engineer, Pennsylvania Railroad; Azel Ames, Jr., Signal Engineer, Electric Zone, New York Central & Hudson River Railroad; J. C. Mock, Electrical Engineer, Detroit River Tunnel Company.

The second edition was prepared under the supervision of the Association's Committee on Definitions, for 1911, namely: J. C. Mock, Electrical Engineer, Detroit River Tunnel Company; C. C. Anthony, Assistant Signal Engineer, Pennsylvania Railroad, and F. P. Patenall, Signal Engineer, Baltimore & Ohio Railroad.

PREFACE TO THE FIRST EDITION

Railway signaling is a comparatively new art, and a rapidly growing one, so that its nomenclature is unsettled and its practices varied; and numerous changes of a somewhat radical nature are still going on. The development of scientific signaling, as distinguished from the earlier and empirical methods of controlling the movements of railway trains, has proceeded from a curious combination of motives; in some cases, from the enterprise of trained men, in others from a pressing necessity due to expansion of business, and in still others to the force of public opinion, both the public and the railway officer being sometimes actuated by injudicious haste. That we are not yet out of the transition state is no cause for surprise.

In making a signaling dictionary the very first step calls for arbitrary action. Hand-motion signaling, with or without the use of flags and lanterns, is excluded, because those features have no need of the services of the signal engineer. A "slow-board" is a fixed signal, but the signal engineer scarcely gives it a thought. On the other hand, automatic bells at highway crossings logically do not come under the head of railway signals, for they do not directly affect the movement of trains; but the signal engineer does take cognizance of this class, because it requires skilled attention and is usually put in his charge.

In fixed signals, which constitute the subject of this work, American railway officers often make a distinction which is wholly arbitrary and, in most cases, useless—that between interlocking signals and block signals. The function of a signal being clearly stated, the English nomenclature, ignoring this distinction, is entirely adequate. But to make each collection of drawings complete in itself, we recognize this distinction; and the reader will find—under the two different heads—different illustrations showing semaphore signals exactly alike.

Other uses of words are inexact, yet not troublesome. The noun "signal" usually means a semaphore signal complete, yet in speaking of the movements of a signal, especially where there are two arms on a single post, "signal" refers to the movable part alone. "Controlled manual" means signals worked by hand but having the hand levers fitted with electric locks by which the man working the signals is subject to the control, under certain circumstances, of the signalman at another station, and also to control by the train itself through track circuits connected with the lever locks; but there are now at least three principal divisions of this subject, so that the simple term "controlled manual" has little meaning until it is explained. It includes: (1) A system worked without track circuits or any other means of control by trains; (2) one worked with a short track circuit at each block station, and (3) with a track circuit throughout the length of the block section.

Practice is more varied than nomenclature; but it is not so inconsistent as it seems, for with suitable limitations of the speeds of trains, supplemented by careful instruction of enginemen, the extreme requirements of the uniformity enthusiasts are not absolutely essential. For example, thousands of miles of railway equipped with home block signals have very few distant signals, and this necessitates slackening of speed in snowstorms and fogs. Many block stations on single-track lines have but one signal for each direction, and both of these are supported on a single post, opposite the station office; but with a rule requiring trains to approach stations with speed under control, this arrangement is workable. On many roads this and other deficiencies of the block system are overcome by continuing in force the time-table regulations. The block system is a valuable means of safety even when worked under these modifications.

Semaphores have wholly superseded disks for signaling at yards and terminals, this for well-known reasons; but disks continue in favor on a few roads for automatic block signaling, and their use is not inconsistent with the use of semaphores. Likewise, the use of semaphores to be inclined upward to indicate "proceed," which is coming into vogue in a few places, is not inconsistent with the old practice, with the downward inclination.

In those drawings which show the color indications used in signals at night, "green or white," referring to home signals, is to be read in connection with "yellow or green," referring to distant signals. Where green means clear, yellow is the color for caution in the distant signal (with an exception as shown). The long-standing and general practice on American railways at night is white for clear, green for caution, red for stop. The other scheme, green for clear, yellow for caution, red for stop, has come into favor within the past 10 years (in England, green for clear became general nearly 20 years ago). Signal engineers are practically unanimous in their view that the abolition of "white" lights for giving signal indications is desirable everywhere.

This work, like the Car Builders' and the Locomotive dictionaries, is necessarily arranged in part like an encyclopedia, for on many subjects the drawings may be called the main feature and the text secondary; and in signaling, far more than in these other arts, extended explanation is necessary in connection with the drawings. The reader will at once recognize the propriety of the arrangement.

The supervising committee and the editors warmly appreciate the courtesies of the railway officers and manufacturers who have furnished drawings and information.

B. B. A.

NEW YORK, March, 1908. R. H.

PREFACE TO THE SECOND EDITION

During the period from 1908 to 1911, inclusive, the developments in railway signaling have been as rapid, as important, and as extensive as in any other previous period of twice this length. The aim in revising this book has been to retain descriptions and illustrations of apparatus which, although no longer made, is and will remain for some time, in rather extensive use, as well as to reflect the latest work of the manufacturers.

Practically all of the standards of the Railway Signal Association as they were listed in the report of the Committee on the Manual at the 1911 convention, with the exception of some designs which are included in the specifications, will be found herein. Some of the drawings shown were submitted for the approval of the association, following the 1911 meeting, and at this writing have not been formally approved. Among these are the standard symbols shown on pages 1 to 13, and the circuits at the end of the section devoted to electric locking.

The arrangement has been changed to mark more distinctly the somewhat arbitrary division of the subjects treated. The descriptive matter is subordinate to the drawings, which form the main feature of each section.

The supervising committee and the editors warmly appreciate the courtesy of the railway officers and manufacturers who have furnished drawings and information for their assistance in the work of revising the dictionary.

A. D. C.
CHICAGO, November, 1911. H. H. S.

A BRIEF RETROSPECT

The block system was first used in America in 1863 or 1864, and interlocking about 1870. Both had been well developed on the busy railways of England, so that American railway officers could find there all necessary examples; but, with our lighter traffic, progress was rather slow. For many years the Pennsylvania, which in 1872 leased the lines east of Philadelphia, on which the block system had been first introduced, was the only road using it. A few roads in New England began using wire-circuit automatic block signals about 1871, but the time-interval rules were maintained in full force, so that the signals were of little use in increasing the capacity of the roads. In 1879 the track circuit was introduced, making automatic block signals effective as against the danger of false clear signals being given by the accidental separation of a train into two parts (and incidentally affording a means of detecting broken rails), and from that time the use of the automatic system has progressed as fast as railways have found themselves able to make the heavy investment necessary to install it. Automatic block signals are now in use on about 20,000 miles of American railways.

Automatic block signals must work without the care of an attendant, and most of them at places remote from a source of power. They were first operated by a simple electro-magnet (the enclosed disk signal), the parts being made very light. To avoid the disadvantage of the glass enclosure the "clock-work" was next introduced, this apparatus furnishing power enough to move a disk exposed to wind, rain, snow and frost. Disks, however, were generally regarded as inferior to semaphores, and the next improvement was the electro-pneumatic mechanism, moving full-sized semaphores, which was introduced in 1885. This system, however, with its air pipe the whole length of every line which is signaled, was too costly for roads with any but the heaviest traffic, and it was not until the perfection of batteries and electric motors capable of economically operating full-size outdoor semaphores (with an independent source of power at each signal) that automatic block signals became universally popular. Since 1900 the electric-motor signal has made great progress and is now used, not only for practically all automatic signaling, but also at the majority of power interlocking plants and at a good many mechanical plants, the introduction of the electro-mechanical interlocking machine having made this latter application practicable. Distant signals are rapidly coming to be motor-operated instead of wire-connected, especially for new work.

Until within the past 10 years single-track lines—with one exception, the Cincinnati, New Orleans & Texas Pacific—made little use of automatic signals, for there are peculiar difficulties on such lines. To make the signals efficient in preventing collisions between trains running in opposite directions the controlling circuits must be more extended and complicated than are those on double track, for each of two trains approaching each other must set signals at "stop" against the opposing train so far in advance of itself as to insure that both trains will receive stop indications in time to stop before meeting. And, in addition, when a train finds a signal at "stop" it must not proceed, as it would on double track, merely looking out for a train standing or moving in the same direction as itself, but must suffer considerable delay by sending a man ahead with a red flag or light, because there is the possibility that a train may be approaching in the opposite direction. In spite of these difficulties, however, automatic signals are being installed in large numbers on single-track lines.

The last three years have witnessed considerable progress in this respect and the mileage of single-track automatic block signals has much more than doubled in that time. Electric railways have been the cause of many of the developments in the application of automatic signals to single track, as their conditions have required such a thorough study of the principles involved that the period of growth and development along this line may be said to have been fairly well completed.

Automatic signals reach their highest application in such installations as those of the New York Subway and the Boston and Philadelphia elevated service, where automatic stops are provided to guard against physical or mental disablement, or carelessness, on the part of the engineman or motorman. The service performed by the signals in such intensive situations is decisively shown by the fact that during the last year the time-speed signals developed in the New York subway have effected a 17 per cent increase in the passenger carrying capacity of the subway lines. Because of the difficulty of maintaining the auxiliary apparatus generally required in connection with an automatic stop on lines exposed to drifting snow and carrying a heavy miscellaneous traffic, and also because of the cost of maintenance and the reduction in the traffic capacity of the railway the automatic stop has not as yet been used except in special conditions like those on the roads named, although much experimenting has been done in the development of these auxiliaries.

City lines of dense traffic, worked by electric power, have also adopted costly inventions, marking notable scientific progress in signaling, made necessary by reason of the use of the rails of the track as conductors for the electric current which propels the trains. To work track-circuit signals on such tracks involves the use of many devices not employed on ordinary railways.

Going back now to non-automatic block signals, the first extension beyond the lines of the Pennsylvania (except about 15 miles on the New York Central) was on single-track lines west of the Alleghenies, where at first the "system" was little more than a rather informal order to telegraph operators to use their train-order signals as block signals. A train-order signal is ordinary employed to stop, for the delivery of written dispatcher's orders, trains which normally would proceed, regardless of the operator, on their time-table rights; and the change was simply to use these signals **to stop every train, unless the last preceding train had reached the next station,** this fact being reported by telegraph from the said next station. But this, simple as it was, and though frequently suspended as regards freight trains, was the essence of the main feature of the block system, and the results justified the practice. Block signaling is not complete and satisfactory without interlocking of all switches; nor without distant signals; nor (if not automatic) without sufficiently frequent stations to obviate the necessity of permissive signaling; but incomplete signaling has proved highly profitable. The least complete space interval system is superior, both in safety and economy, to any scheme of time intervals, with its dependence on complicated rules, and the careful use of flags, torpedoes and fusees; on a high degree of vigilance in conductors and flagmen

and the special skill of dispatchers and station operators.

Since 1898 the use of manual block signaling has been quite rapidly extended throughout the country, and it now covers over 50,000 miles of road, besides several thousands more on which the protection is less complete. This manual signaling is on lines which carry a considerable traffic, but which yet are not profitable enough to justify the initial expenditure necessary to install automatic signals. But as fast as automatics can be afforded many companies are substituting them for the other system; for, once installed, their operation, requiring no signalmen, is much less costly.

The alternating current has been applied both to steam and electric railways with such good results from the standpoint of economic installation and maintenance that its future is very promising for automatic signaling in general.

From the beginning, in 1870 or 1871, interlocking made slow but sure progress. In the large passenger terminals it was soon seen to be an absolute necessity, because without it the excessive cost of the wages of signalmen at detached switches, the danger of collisions due to imperfect hand-signaling and to fog, and the intolerable delays necessary to guard against these dangers, often put a serious embargo on traffic. The question of interlocking thus was largely one of economy rather than a safety, and the improvement was introduced mainly at terminal yards and junctions and crossings. (At crossings it economized time, fuel and wear by making unnecessary the stop for every train formerly required at all grade crossings.) But as speeds of trains increased interlocking was found useful at all stations where much switching was done, for it obviates the slackening of the speed of fast trains, and our best lines now have interlocking for all their busiest stations.

Power operation of switches (and signals) familiarly termed "power interlocking" came into use with electro-pneumatic block signals. Following this, machines working wholly by electric power were tried as soon as electric motors were sufficiently developed, and the "low-pressure" pneumatic, with no electric apparatus, came soon after. The "all-electric" did not come into general use until about 1900; but it has now supplanted the "all-air." At small, isolated plants it is economical because of the simplicity of the engine (gasoline) and generator necessary to produce the electric current.

The upper quadrant has made steady progress, and is now used on about 100,000 miles of railway. Green for clear has made rapid strides in replacing the white light, and its application covers 115,000 miles.

The work of both the signal departments and manufacturers in late years has been along the line of improving what already exists quite as much as in extending the use of signaling apparatus. And now the interest of the signal department in the installation by no means ceases when it has been completed and put in service, for the question of economy in operation has assumed an importance almost equivalent to the original selection of the material to be used. It has become a matter of fact that some of the old methods of handling and operating signaling apparatus are not as economical as they must become to keep pace with the efficiency movement in all lines of work.

This book is not a history; and, indeed, much of the best history in this field is too recent to be satisfactorily written; but the foregoing paragraphs will serve to give the reader who is not familiar with the subject some idea of the reasons for the existence of the extensive and varied art which is illustrated in the following pages. Signaling now engages the attention of the best engineering talent on all the best railways. The signal manufacturing companies of the country employ millions of capital, and their engineers have met, and are meeting, innumerable abstruse and intricate problems, with brilliant success. American signalmen have accomplished both progress and economy, and new economies are still being effected.

USE OF THE BLOCK SYSTEM IN THE UNITED STATES

TABLE PUBLISHED BY THE INTERSTATE COMMERCE COMMISSION, JANUARY 1, 1911, SHOWING THE AGGREGATE LENGTH OF LINES OR PARTS OF LINES OF RAILROADS IN THE UNITED STATES ON WHICH THE BLOCK SYSTEM IS IN USE (MILES OF ROAD).

The use of alternating current in connection with signal installations is reported as follows:

Auburn & Northern, Cumberland Valley, Hudson & Manhattan, and Syracuse, Lake Shore & Northern. All automatic signals are controlled by a. c. track circuits and operated by a. c. signal circuits.

Long Island: 77.7 miles a. c. track circuits; 56.2 miles of track on which a. c. electric-motor signals are used.

New York, New Haven & Hartford: 71.4 miles a. c. track circuits with automatic signals; 85.8 miles a. c. track circuits with controlled manual signals; 8.1 miles double track and 9.2 miles six-track road on which a. c. motor signals are used.

Northwestern Pacific: a. c. track circuits used to control all automatic signals; on 6 miles of track a. c. electric-motor signals are used.

Pennsylvania: 33.5 miles a. c. track circuits Philadelphia, Baltimore & Washington; 5.2 miles a. c. track circuits; West Jersey & Seashore, 76.3 miles a. c. track circuits.

Automatic train stops are used in connection with block signals on the Erie, the Hudson & Manhattan, the New York City Terminal of the Pennsylvania, and the suburban lines of the Washington Water Power Company. On the Erie the Harrington automatic stop is used on 11.8 miles of one track of double track road. On the Hudson & Manhattan automatic stops are used in connection with all signals. In the Pennsylvania Terminal in New York automatic stops are used in connection with signals throughout the tunnels, covering 4.4 miles of road, or 13.7 miles of track. The Washington Water Power Company uses automatic stops in connection with automatic signals on 29 miles of track.

The Delaware, Lackawanna & Western and the Tide Water Power Company operate a few miles of road by means of the train staff without electric control. So far as known, these are the only two installations of this form of block system. The installation on the Delaware, Lackawanna & Western is on a section of road which is used only for freight trains.

AGGREGATE LENGTH OF LINES AND PARTS OF LINES ON WHICH THE BLOCK SYSTEM WAS IN USE ON JANUARY 1, 1911

Names of railroads.	Permissive signaling forbidden.		Permissive signaling allowed.						Rear-end protection only.		Stop at station recognized as stop for signal opposite office.	
			By three-position signal.		By two-position signal and flag or lantern.		By caution card.					
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.
Ann Arbor	1.4	1.4										
Atchison, Topeka & Santa Fe:												
Eastern lines			[1] 841.9	1,343.0			[1] 7.7	7.7				
Western lines			[1] 559.9	561.1			[1] 28.5	28.5				
Coast lines	4.3	4.3										
Gulf, Colorado & Santa Fe							[1] 2.1	2.1				
Atlantic Coast Line	56.5	105.6					418.3	464.9	373.1	373.1	474.8	570.0
Baltimore & Ohio	160.2	221.2	886.5	1,626.7								
Baltimore & Ohio Southwestern			960.0	1,001.9					960.0	1,001.9	960.0	1,001.9
Baltimore & Sparrow's Point			4.7	7.7								
Bessemer & Lake Erie	.9	.9					193.8	324.2				
Boston & Maine	4.8	9.6										
Buffalo, Rochester & Pittsburgh					[2] 429.9	558.7			429.9	558.7		
Central New England	16.0	16.0										
Central of Georgia	59.7	67.1										
Chesapeake & Ohio							[1] 1,400.1	1,526.0				
Chesapeake & Ohio Ry. of Indiana							269.0	269.0				
Chicago & Alton							[2] 141.2	141.2				
Chicago & Eastern Illinois	13.0	13.0	[1] 218.4	218.4								
Chicago & North Western							[1,2] 2,524.6	2,639.9			2,524.6	2,639.9
Chicago & Western Indiana					9.5	22.2					9.5	22.2
Chicago, Burlington & Quincy			[1] 8,637.3	9,274.2					6,303.3	6,303.3	8,690.6	9,327.5
Chicago Great Western	1.5	1.5					[1] 1,329.4	1,353.1			1,330.9	1,354.6
Chicago, Indianapolis & Louisville			525.0	525.0								
Chicago, Milwaukee & St. Paul	187.3	187.3					[2] 3,619.7	4,058.5				
Chicago, Milwaukee & Puget Sound	2.0	2.0	[2] 1,362.7	1,362.7			[2] 1,362.7	1,362.7				
Chicago, Rock Island & Pacific			[1] 9.0	9.0			[1] 988.7	988.7			997.7	997.7
Chicago, St. Paul, Minneapolis & Omaha							[2,3] 656.0	720.1				
Cincinnati, Hamilton & Dayton			33.9	47.8							33.9	47.8
Cincinnati, Indianapolis & Western							[2] 99.0	99.0			99.0	99.0
Colorado Midland	2.0	2.0										
Cornwall & Lebanon					[2] 22.0	35.7						
Cumberland & Pennsylvania			[2] 7.3	13.3								
Cumberland Valley	2.0	2.0	17.6	17.6								
Delaware, Lackawanna & Western	5.8	5.8										
Duluth & Iron Range			16.2	17.6								
Durham & Southern									56.0	56.0		
Elgin, Joliet & Eastern					11.3	11.3						
Erie			[2] 1,075.8	1,508.1							1,075.8	1,508.1
Chicago & Erie			[2] 248.8	257.2							248.8	257.2
Columbus & Erie			[2] 22.4	32.2							22.4	32.2
New Jersey & New York			26.1	26.1							26.1	26.1
New York, Susquehanna & Western			[2] 34.7	53.4								
Evansville & Terre Haute			108.5	108.5	108.5	108.5						
Great Northern	18.7	18.7			[1,2] 239.8	239.8	[1,2] 239.8	239.8				
Hocking Valley			144.0	144.0								
Illinois Central	14.0	19.0										
Illinois Traction	24.0	24.0										
Iowa Central					[2] 11.0	11.0						
Kanawha & Michigan	1.3	1.3										
Kansas City, Clinton & Springfield	2.5	2.5										
Kentucky & Indiana Bridge & R. R. Co.			11.1	17.9								
Kentwood & Eastern	3.3	3.3										
Lackawanna & Wyoming Valley	3.4	5.8										
Lehigh Valley	714.3	776.7										
Long Island							22.7	45.4				
Louisville & Nashville			495.9	599.5								
Marquette & Southeastern			3.7	3.7								
Minneapolis, St. Paul & Sault Ste. Marie	54.9	54.9					[2] 2,396.3	2,400.7				
Missouri Pacific	5.7	5.7					12.9	19.9				
St. Louis, Iron Mountain & Southern	12.7	14.3										
Missouri, Kansas & Texas	8.6	8.6										
Mobile & Ohio							[2] 47.8	47.8	47.8	47.8	47.8	47.8
Nashville, Chattanooga & St. Louis			[1] 104.6	116.4								
Newburgh & South Shore					6.2	11.4			6.2	11.4	6.2	11.4
New York Central Lines:												
Boston & Albany	1.9	3.7										
Chicago, Indiana & Southern							203.7	263.6				
Cleveland, Cincinnati, Chicago & St. Louis	905.2	1,267.5			19.3	19.3			22.6	22.6	838.1	1,188.6
Lake Erie & Western	18.6	18.6	[2] 853.3	862.3								
Lake Shore & Michigan Southern							[1] 1,056.1	1,128.0	996.0	996.0	1,056.1	1,128.0
Dunkirk, Allegheny Valley & Pittsburg							[1] 90.5	90.5	90.5	90.5	90.5	90.5
Lake Erie, Alliance & Wheeling							[1] 87.7	87.7	87.7	87.7	87.7	87.7
Michigan Central	920.3	939.7									920.3	939.7
New York Central & Hudson River	2,345.1	3,379.1			129.6	231.3						
Peoria & Eastern	82.2	84.7			4.3	4.3					84.0	84.0
Pittsburg & Lake Erie	22.7	25.6										
New York, New Haven & Hartford	6.3	6.3					[2] 429.5	862.6	87.5	87.5	177.5	225.4
Norfolk & Western	12.9	12.9	[1] 1,056.5	1,135.1	[1] 222.0	229.1			910.7	910.7		
Northern Pacific	1.3	1.3					992.2	1,277.7			992.2	1,277.7
Northwestern Pacific	250.5	250.5										

[1] Permissive signaling is practiced only in the case of a freight train following a freight train, or in similar movements where neither train carries passengers.
[2] By dispatcher. [3] By rule.

AGGREGATE LENGTHS OF LINES AND PARTS OF LINES ON WHICH THE BLOCK SYSTEM WAS IN USE ON JANUARY 1, 1911—Continued

Names of railroads.	Automatic block signals.						Nonautomatic block signals.						Total automatic and nonautomatic.		Total passenger lines operated.		Percentage block-signaled (miles of track).
	Single track.	Double track.	Three track.	Four track.	Total.		Single track.	Double track.	Three track.	Four track.	Total.		Miles of road.	Miles of track.	Miles of road.	Miles of track.	
					Miles of road.	Miles of track.					Miles of road.	Miles of track.					
Illinois Traction							24.0				24.0	24.0	24.0	24.0	415.0	415.0	5.7
Iowa Central							11.0				11.0	11.0	11.0	11.0	503.0	503.0	2.2
Kanawha & Michigan	.8				.8	.8	1.3				1.3	1.3	2.1	2.1	162.9	162.9	1.3
Kansas City, Clinton & Springfield							2.5				2.5	2.5	2.5	2.5	156.7	156.7	1.6
Kentucky & Indiana Bridge & R. R. Co.							4.8	5.8	.5		11.1	17.9	11.1	17.9	11.1	17.9	100.0
Kentwood & Eastern							3.3				3.3	3.3	3.3	3.3	30.0	30.0	11.0
Lackawanna & Wyoming Valley							1.0	2.4			3.4	5.8	3.4	5.8	22.6	43.4	13.3
Lehigh & New England	.7				.7	.7							.7	.7	67.2	67.2	.....
Lehigh Valley	14.1	439.3	34.6	13.0	501.0	1,048.6	652.0	62.3			714.3	776.7	1,215.3	1,825.3	1,171.5	1,741.3	100.0
Long Island	4.0	96.8	3.3	8.8	112.9	242.7		22.7			22.7	45.4	135.6	288.1	391.9	549.5	52.4
Louisville & Nashville	40.9	22.3			63.2	85.5	392.3	103.6			495.9	599.5	559.1	685.0	4,372.0	4,543.0	15.1
Maine Central	415.1	57.7			472.8	530.5							472.8	530.8	907.6	967.2	54.8
Marquette & Southeastern							3.7				3.7	3.7	3.7	3.7	50.8	50.8	7.3
Minneapolis, St. Paul & Sault Ste. Marie							2,446.8	4.4			2,451.2	2,455.6	2,451.2	2,455.6	3,423.4	3,427.8	71.6
Missouri, Kansas & Texas	5.9				5.9	5.9	8.6				8.6	8.6	14.5	14.5	3,072.0	3,072.0	.2
Missouri Pacific	55.2	25.7			80.9	106.0	11.6	7.0			18.6	25.6	99.5	131.6	3,708.4	3,767.0	2.5
St. Louis, Iron Mountain & Southern	113.8	8.6			122.4	131.0	11.1	1.6			12.7	14.3	135.1	145.3	3,178.5	3,318.8	4.4
Mobile & Ohio		4.7			4.7	9.4	47.8				47.8	47.8	52.5	57.2	825.0	825.0	6.9
Monongahela	.5				.5	.5							.5	.5	66.7	66.7	.7
Nashville, Chattanooga & St. Louis							92.8	11.8			104.6	116.4	104.6	116.4	1,230.1	1,241.9	9.3
Newburgh & South Shore							1.0	5.2			6.2	11.4	6.2	11.4	Freight line.		
New York & Long Branch		38.0			38.0	76.0							38.0	76.0	38.0	76.0	100.0
New York Central lines:																	
Boston & Albany		132.9	50.1	23.6	206.6	510.6		1.9			1.9	3.7	208.5	514.3	351.6	602.0	85.4
Chicago, Indiana & Southern		5.0			5.0	10.0	143.8	50.9			203.7	263.6	208.7	273.6	309.4	374.3	73.1
Cleveland, Cincinnati, Chicago & St. Louis							562.7	361.8			924.5	1,286.8	924.5	1,286.8	1,832.9	2,214.7	59.9
Lake Erie & Western							862.9	9.0			871.9	880.9	871.9	880.9	832.5	841.5	100.0
Lake Shore & Michigan Southern	6.9	173.2	98.4	240.3	518.8	1,609.7	996.0	48.3	11.8		1,056.1	1,128.0	1,574.9	2,737.7	1,452.7	2,596.6	100.0
Dunkirk, Allegheny Valley & Pittsburg							90.5				90.5	90.5	90.5	90.5	90.5	90.5	100.0
Lake Erie, Alliance & Wheeling							87.7				87.7	87.7	87.7	87.7	87.7	87.7	100.0
Michigan Central [1]		271.9			271.9	543.9	901.0	19.3			920.3	939.6	1,192.2	1;483.5	1,192.2	1,483.5	100.0
New York Central & Hudson River	2.0	262.4	6.3	110.8	381.5	988.7	1,632.0	688.5	15.4	138.8	2,474.7	3,610.4	2,856.2	4,599.1	2,873.7	4,674.5	98.4
Peoria & Eastern							84.0	2.5			86.5	89.0	86.5	89.0	337.9	340.4	26.1
Pittsburg & Lake Erie		101.8		47.0	148.8	391.6	19.8	2.9			22.7	25.6	171.5	417.2	183.9	420.4	99.2
New York, New Haven & Hartford [2]	17.5	245.0		9.2	271.7	562.7	154.3	205.7		75.8	435.8	868.9	707.5	1,431.6	1,926.4	2,967.1	47.7
New York, Ontario & Western	36.0	111.6			147.6	259.2							147.6	259.2	492.8	626.2	41.4
Norfolk & Western	68.0	272.8			340.8	613.6	1,245.3	66.1			1,311.4	1,377.5	1,652.2	1,991.1	1,671.6	2,025.5	97.1
Northern Pacific	101.5	136.7			238.2	374.9	708.0	285.5			993.5	1,279.0	1,231.7	1,653.9	5,303.4	5,752.6	28.7
Northwestern Pacific	2.5	11.4			13.9	25.4	250.5				250.5	250.5	264.4	275.9	330.6	342.0	80.7
Pennsylvania [2]		58.0	4.9	200.0	262.9	934.2	1,428.2	708.3	25.8	199.2	2,361.5	3,769.0	2,624.4	4,703.2	3,261.0	5,479.5	85.8
Cleveland, Akron & Columbus							126.5	17.4			143.9	161.3	143.9	161.3	177.8	195.8	82.4
Cincinnati & Muskingum Valley							11.4				11.4	11.4	11.4	11.4	148.4	148.4	7.7
Grand Rapids & Indiana							55.8	2.2			58.0	60.2	58.0	60.2	536.7	547.3	11.0
Northern Central							287.1	120.1		20.5	427.7	609.3	427.7	609.3	439.7	635.9	95.7
Pennsylvania Company		273.7	23.3	47.3	344.3	806.5	418.9	325.0	5.2		749.1	1,084.5	1,093.4	1,891.0	1,315.0	2,125.6	89.0
Philadelphia, Baltimore & Washington		18.2		21.0	39.2	121.7	154.5	147.0	17.1	15.3	333.9	561.0	373.1	682.7	639.4	945.5	72.2
Pittsburg, Cincinnati, Chicago & St. Louis		7.8		3.4	11.2	29.2	507.2	515.4	58.9	20.6	1,102.1	1,797.1	1,113.3	1,826.3	1,415.3	2,140.7	85.3
West Jersey & Seashore		87.1	6.3		93.4	193.1	47.1	33.0			80.1	113.1	173.5	306.2	318.2	455.6	67.2
Vandalia							300.9	61.0			361.9	422.8	361.9	422.8	797.0	868.1	48.9
Peoria & Pekin Union								6.0			6.0	12.0	6.0	12.0	15.4	26.6	48.8
Pere Marquette	15.2				15.2	15.2	39.0				39.0	39.0	54.2	54.2	1,534.2	1,541.4	3.5
Philadelphia & Reading	6.2	324.0	42.1	14.0	386.3	836.5	143.6	96.9			240.5	337.4	626.8	1,173.9	875.3	1,452.3	80.8
Atlantic City		86.9			86.9	173.8	35.7				35.7	35.7	122.6	209.5	163.6	251.6	83.3
Northeast Pennsylvania	2.8	1.8			4.6	6.4	1.6				1.6	1.6	6.2	8.0	25.5	27.3	29.3
Perkiomen							38.1				38.1	38.1	38.1	38.1	38.1	38.1	100.0
Philadelphia, Newtown & New York	3.8	1.8	1.5		7.1	11.9							7.1	11.9	21.7	26.6	44.7
Reading & Columbia							35.9				35.9	35.9	35.9	35.9	53.3	53 3	67.4
Quincy, Omaha & Kansas City and Iowa & St. Louis							305.0				305.0	305.0	305.0	305.0	305.0	305.0	100.0
Queen & Crescent Route:																	
Alabama Great Southern	91.7	.4			92.1	92.5							92.1	92.5	290.6	295.4	31.7
Cincinnati, New Orleans & Texas Pacific	264.9	69.2			334.1	403.4	.7				.7	.7	334.8	404.1	335.4	404.6	99.8
New Orleans & Northeastern		15.5			15.5	31.0							15.5	31.0	15.5	31.0	14.7
Richmond, Fredericksburg & Potomac							9.0	78.7			87.7	166.4	87.7	166.4	87.7	166.4	100.0
St. Joseph & Grand Island							.3				.3	.3	.3	.3	251.6	251.6	
St. Louis & San Francisco	562.3	37.8			600.1	637.9	157.3				157.3	157.3	757.4	795.2	4,726.6	4,764.4	16.7
Beaumont, Sour Lake & Western							84.7				84.7	84.7	84.7	84.7	117.0	117.0	72.3
New Orleans, Texas & Mexico							157.6				157.6	157.6	157.6	157.6	265.6	265.6	60.5
Orange & Northwestern							61.6				61.6	61.6	61.6	61.6	61.6	61.6	100.0
St. Louis Merchants Bridge Terminal		5.9			5.9	11.8		1.1			1.1	2.2	7.0	14.0	10.0	19.8	77.7
St. Louis Southwestern	.4				.4	.4							.4	.4	622.7	622.7	
San Francisco, Oakland & San Jose Consolidated		3.9			3.9	7.8							3.9	7.8	15.7	27.7	28.5
San Pedro, Los Angeles & Salt Lake	1.1				1.1	1.1							1.1	1.1	904.4	904.4	.1
Seaboard Air Line							213.5				213.5	213.5	213.5	213.5	2,782.9	2,782.9	7.6
Southern		3.0			3.0	6.0	1,588.3	247.3			1,835.6	2,082.9	1,838.6	2,088.9	6,619.6	6,898.6	30.3
Southern Illinois & Missouri Bridge		4.6			4.6	9.2							4.6	9.2	4.6	9.2	100.0
Southern Pacific, Atlantic System:																	
Galveston, Harrisburg & San Antonio	279.1				279.1	279.1							279.1	279.1	1,270.5	1,275.0	21.9
Louisiana Western	103.6				103.6	103.6							103.6	103.6	140.3	140.3	73.9
Morgan's Louisiana & Texas	95.3				95.3	95.3							95.3	95.3	241.9	282.1	33.8
Texas & New Orleans	109.8				109.8	109.8							109.8	109.8	438.4	441.8	24.9
Southern Pacific: Pacific System	2,189.2	164.9		1.0	2,355.1	2,523.0	98.0				98.0	98.0	2,453.1	2,621.0	6,447.7	6,671.4	39.3
Staten Island Rapid Transit		10.9			10.9	21.7							10.9	21.7	10.1	20.1	96.5
Staten Island							2.5	10.2			12.7	22.8	12.7	22.8	12.7	22.8	100.0
Spokane, Portland & Seattle								10.0			10.0	20.0	10.0	20.0	422.0	432.0	4.6
Syracuse, Lake Shore & Northern		6.5			6.5	13.0							6.5	13.0	33.0	44.5	27.6
Terminal R. R. Association of St. Louis		6.0			6.0	12.0		1.1			1.1	2.2	7.1	14.2	12.7	25.5	55.7
Tidewater Power Co.							6.2				6.2	6.2	6.2	6.2	11.3	15.7	39.5
Toledo, Peoria & Western							.3				.3	.3	.3	.3	220.0	220.0	.1
Toledo, St. Louis & Western							188.0				188.0	188.0	188.0	188.0	451.0	451.0	41.7
Ulster & Delaware	24.4				24.4	24.4							24.4	24.4	126.3	126.3	19.8
Union		.6			.6	1.2	1.4				1.4	1.4	2.0	2.6	7.4	14.8	17.6
Union Pacific	871.0	551.0		1.7	1,423.7	1,979.1	11.4				11.4	11.4	1,435.1	1,990.5	3,467.3	4,088.2	48.7
Oregon R. R. & Navigation Co.	433.0				433.0	433.0							433.0	433.0	1,140.9	1,140.9	37.0
Oregon Short Line	551.5	25.7			577.2	602.9							577.2	602.9	1,442.4	1,468.1	41.0
Virginia & Kentucky							.6				.6	.6	.6	.6	4.8	4.8	12.5
Virginian							2.2				2.2	2.2	2.2	2.2	435.6	435.6	.5
Wabash		7.2			7.2	14.4	1,726.7	94.0			1,820.7	1,914.7	1,827.9	1,929.1	1,954.9	2,056.1	93.8
Wabash Pittsburg Terminal		4.1			4.1	8.2							4.1	8.2	59.8	63.9	12.8
Washington Southern								32.2			32.2	64.4	32.2	64.4	32.2	64.4	100.0
Washington Terminal [2]		1.1		1.0	2.1	20.4							2.1	20.4	2.1	20.4	100.0
Washington Water Power Co.	29.0				29.0	29.0							29.0	29.0	29.0	29.0	100.0
Western Pacific	11.2				11.2	11.2							11.2	11.2	921.6	921.6	1.2
Total	8,312.2	8,225.4	331.2	842.7	17,711.5	29,202.4	44,897.1	7,913.1	257.9	489.5	53,557.6	63,505.5	71,269.1	92,707.9	172,389.9	195,922.4	.....

[1] (Michigan Central.) 243.1 miles double track automatic block in Canada not shown in these tables.
[2] (Illinois Central; New York, New Haven & Hartford; Pennsylvania; Washington Terminal.) Include road with more than 4 tracks.

KINDS OF AUTOMATIC SIGNALS IN USE

Names of railroads.	Exposed disk.		Inclosed disk.		Semaphores. Electropneumatic.		Semaphores. Electric motor.		Semaphores. Electro-gas.		Normal clear (miles of track).	Normal danger (miles of track).	Total automatic signals.		
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.			Miles of road.	Miles of track.	Number of block sections.
Atchison, Topeka & Santa Fe:															
Eastern lines			13.3	26.6			66.0	126.3			152.9		79.3	152.9	92
Western lines							35.8	38.2			38.2		35.8	38.2	36
Coast lines			5.4	5.4			14.5	15.5			20.9		19.9	20.9	19
Gulf, Colorado & Santa Fe			8.3	8.3			2.5	2.5			10.8		10.8	10.8	8
Atlantic Coast Line							15.2	28.3			28.3		15.2	28.3	35
Auburn & Northern							6.5	6.5			6.5		6.5	6.5	3
Baltimore & Ohio			9.9	9.9	7.5	22.4	107.1	211.6	93.6	186.2		430.1	218.1	430.1	602
Baltimore & Ohio Chicago Terminal			1.0	2.0			9.8	18.8			20.8		10.8	20.8	32
Baltimore & Ohio Southwestern							14.0	28.0				28.0	14.0	28.0	35
Boston & Maine			.8	1.6			687.4	1,254.3	8.9	17.8	1,254.3	19.4	697.1	1,273.7	1,615
Boston, Revere Beach & Lynn							13.8	27.6			27.6		13.8	27.6	59
Butte, Anaconda & Pacific			7.9	7.9							7.9		7.9	7.9	7
Central of New Jersey					29.7	116.0	163.3	323.2	19.4	38.0	439.2	38.0	212.4	477.2	734
Chesapeake & Ohio							183.0	366.0			366.0		183.0	366.0	292
Chicago & Alton							561.0	705.9			183.0	522.9	561.0	705.9	368
Chicago & Eastern Illinois [1]			8.7	13.8			98.4	196.8			210.6		107.1	210.6	165
Chicago & North Western			736.5	1,498.8	2.9	5.8					1,504.6		739.4	1,504.6	1,162
Chicago & Western Indiana							17.8	35.6			35.6		17.8	35.6	59
Chicago, Burlington & Quincy			23.0	46.0	2.0	8.0	17.4	43.2			97.2		42.4	97.2	38
Chicago Great Western							125.9	190.8			190.8		125.9	190.8	182
Chicago, Milwaukee & St. Paul			2.4	2.4			103.7	207.4	3.5	3.5	197.4	15.9	109.6	213.3	203
Chicago, Peoria & St. Louis Ry. of Ill.							1.3	1.3			1.3		1.3	1.3	1
Chicago, Rock Island & Pacific			6.0	12.0			926.9	1,200.5			1,209.5	3.0	932.9	1,212.5	1,252
Chicago, Rock Island & Gulf							32.6	32.6			32.6		32.6	32.6	50
Chicago, St. Paul, Minneapolis & Omaha							6.2	12.4			12.4		6.2	12.4	6
Cincinnati, Hamilton & Dayton							34.3	48.6			48.6		34.3	48.6	78
Cumberland Valley							6.7	13.4			13.4		6.7	13.4	13
Delaware & Hudson			38.4	76.8					371.6	619.5		696.3	410.0	696.3	1,013
Delaware, Lackawanna & Western			26.6	51.2			558.1	1,065.1			1,116.3		584.7	1,116.3	1,558
Elgin, Joilet & Eastern							5.0	8.0			8.0		5.0	8.0	5
Erie							227.1	484.0			5.2	478.8	227.1	484.0	579
Erie & Jersey							42.3	84.6			84.6		42.3	84.6	88
New Jersey & New York							10.5	21.0				21.0	10.5	21.0	22
Grand Trunk					2.7	4.3					4.3		2.7	4.3	3
Great Northern							130.8	253.1			251.1	2.0	130.8	253.1	219
Illinois Central			29.5	104.2			118.8	186.9	163.9	329.8	254.6	366.3	312.2	620.9	535
Yazoo & Mississippi Valley							6.6	6.6			6.6		6.6	6.6	8
Kanawha & Michigan							.8	.8			.8		.8	.8	1
Lehigh & New England							.7	.7			.7		.7	.7	1
Lehigh Valley			251.2	534.6			233.8	482.0	16.0	32.0		1,048.6	501.0	1,048.6	1,068
Long Island							112.9	242.7			238.7	4.0	112.9	242.7	386
Louisville & Nashville							63.2	85.5			85.5		63.2	85.5	132
Maine Central							472.8	530.5			530.5		472.8	530.5	542
Missouri, Kansas & Texas			.5	.5			5.4	5.4			5.9		5.9	5.9	8
Missouri Pacific							80.9	106.0			106.0		80.9	106.0	90
St. Louis, Iron Mountain & Southern							122.4	131.0			131.0		122.4	131.0	122
Mobile & Ohio							4.7	9.4			9.4		4.7	9.4	3
Monongahela							.5	.5			.5		.5	.5	1
New York & Long Branch							38.0	76.0			76.0		38.0	76.0	118
New York Central Lines:															
Boston & Albany [2]	16.2	33.3					182.5	447.7	7.2	14.4	154.9	350.5	205.9	495.4	634
Chicago, Indiana & Southern							5.0	10.0			10.0		5.0	10.0	19
Lake Shore & Michigan Southern			5.3	5.3			336.4	928.9	177.1	675.5	934.2	675.5	518.8	1,609.7	1,611
Michigan Central [3]			67.5	134.9			193.8	387.6			522.5		261.3	522.5	359
New York Central & Hudson River [4]			9.9	19.7			416.0	944.7	8.1	16.2	695.4	285.2	379.4	980.6	1,282
Pittsburg & Lake Erie							148.8	391.6			391.6		148.8	391.6	207
New York, New Haven & Hartford	177.1	338.3	64.7	129.4			29.9	95.0			562.7		271.7	562.7	591
New York, Ontario & Western	65.6	100.9					82.0	158.3			259.2		147.6	259.2	150
Norfolk & Western					.7	.7	340.1	612.9			612.9	.7	340.8	613.6	594
Northern Pacific			1.5	1.5			236.2	372.4	.5	1.0	374.9		238.2	374.9	401
Northwestern Pacific							13.9	25.4			25.4		13.9	25.4	42
Pennsylvania [5]			5.0	10.0	242.3	874.8	10.6	21.2			906.0		257.9	906.0	1,556
Pennsylvania Co.							344.3	806.5			806.5		344.3	806.5	1,082
Philadelphia, Baltimore & Washington					39.2	121.7					121.7		39.2	121.7	150
Pittsburg, Cincinnati, Chicago & St. Louis							11.2	29.2			29.2		11.2	29.2	70
West Jersey & Seashore					93.4	193.1					193.1		93.4	193.1	249
Pere Marquette			10.0	10.0			5.2	5.2			15.2		15.2	15.2	11
Philadelphia & Reading [6]			386.6	837.3	1.0	2.0			14.0	20.1	2.0	857.4	401.6	859.4	993
Atlantic City			86.9	173.8								173.8	86.9	173.8	93
Northeast Pennsylvania			4.6	6.4								6.4	4.6	6.4	8
Philadelphia, Newtown & New York			7.1	11.9								11.9	7.1	11.9	16
Queen & Crescent Route:															
Alabama Great Southern	29.0	29.0	9.0	9.0			54.1	54.5			92.5		92.1	92.5	62
Cincinnati, New Orleans & Texas Pacific	35.3	35.3	56.6	56.6			240.2	309.5	2.0	2.0	374.6	28.8	334.1	403.4	326
New Orleans & Northeastern							15.5	31.0			31.0		15.5	31.0	16
St. Louis & San Francisco			3.9	7.8			596.2	630.1			630.1	7.8	600.1	637.9	553
St. Louis Merchants' Bridge Terminal							5.9	11.8			11.8		5.9	11.8	30
St. Louis Southwestern							.4	.4			.4		.4	.4	1
San Francisco, Oakland & San Jose Consolidated							3.9	7.8			7.8		3.9	7.8	76
San Pedro, Los Angeles & Salt Lake			1.1	1.1							1.1		1.1	1.1	1
Southern							3.0	6.0			6.0		3.0	6.0	9
Southern Illinois & Missouri Bridge							4.6	9.2			9.2		4.6	9.2	18
Southern Pacific—Atlantic System:															
Galveston, Harrisburg & San Antonio							279.1	279.1			279.1		279.1	279.1	204
Louisiana Western							103.6	103.6			103.6		103.6	103.6	73
Morgan's Louisiana & Texas							95.3	95.3			95.3		95.3	95.3	72
Texas & New Orleans							109.8	109.8			109.8		109.8	109.8	77
Southern Pacific—Pacific System			1.0	1.0	6.0	14.0	2,348.1	2,508.0			2,523.0		2,355.1	2,523.0	2,177
Staten Island Rapid Transit			10.9	21.7							21.7		10.9	21.7	50
Syracuse, Lake Shore & Northern							6.5	13.0			13.0		6.5	13.0	26
Terminal R. R. Association of St. Louis							6.0	12.0			12.0		6.0	12.0	16
Ulster & Delaware							24.4	24.4			24.4		24.4	24.4	20
Union			.6	1.2							1.2		.6	1.2	2
Union Pacific			8.9	15.1			1,381.5	1,902.1	33.3	61.9	1,979.1		1,423.7	1,979.1	1,585
Oregon R. R. & Navigation Co.							433.0	433.0			433.0		433.0	433.0	308
Oregon Short Line			10.4	10.4			566.8	592.5			602.9		577.2	602.9	463
Wabash							7.2	14.4			14.4		7.2	14.4	25
Wabash Pittsburg Terminal					4.1	8.2					8.2		4.1	8.2	11
Washington Terminal					2.1	20.4						20.4	2.1	20.4	13
Washington Water Power Co.							29.0	29.0			29.0		29.0	29.0	23
Western Pacific							11.2	11.2			11.2		11.2	11.2	8
Total	323.2	536.8	1,920.9	3,866.1	433.6	1,391.4	14,167.6	21,339.4	919.1	2,017.9	23,058.9	6,092.7	17,709.8	29,151.6	29,881

[1] (Chicago & Eastern Illinois.) The figures in this table include 8.7 miles of inclosed disk signals used in manual block territory which are not shown in Table 1

[2] (Boston & Albany.) 1.7 miles of road, 5.2 miles of track protected by slotted signals not shown in this table.

[3] (Michigan Central.) 10.6 miles semiautomatic and slotted signals not shown in this table.

[4] (New York Central & Hudson River.) 2 miles 4-track, light signals, not shown in this table. The apparent discrepancy in road mileage in this table is due to the fact that different types of signals are used on the different tracks of 4-track sections of road.

[5] (Pennsylvania.) 5 miles of road, 28.2 miles of track protected by light signals not shown in this table.

[6] (Philadelphia & Reading.) Includes 15.3 miles of road used exclusively for freight trains not shown in Table 1.

METHODS AND APPARATUS USED WITH MANUAL BLOCK SYSTEM

Names of railroads.	Telegraph.		Telephone.		Electric bells.		Controlled manual.						Electric train staff.		Block signal stations.	
							No track circuit.		Track circuit at stations.		Continuous track circuit.					
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Total number.	Number closed part time.
Ann Arbor			1.4	1.4											2	
Atchison, Topeka & Santa Fe:																
Eastern lines			841.9	1,343.0									7.7	7.7	175	51
Western lines [1]			559.9	561.1									28.5	28.5	115	16
Coast lines													4.3	4.3	4	
Gulf, Colorado & Santa Fe													2.1	2.1	2	
Atlantic Coast Line [2]	180.2	223.4	294.6	346.6											121	18
Baltimore & Ohio	1,035.8	1,837.0	3.7	3.7							7.2	7.2			292	8
Baltimore & Ohio Southwestern	960.0	1,001.9													187	69
Baltimore & Sparrow's Point			4.7	7.7											3	2
Bessemer & Lake Erie	190.2	320.6											4.5	4.5	48	6
Boston & Maine									4.8	9.6					2	
Buffalo, Rochester & Pittsburg	429.9	558.7													98	45
Central New England [3]											14.7	14.7	1.3	1.3	7	
Central of Georgia	59.7	67.1													19	3
Chesapeake & Ohio	1,080.6	1,132.3	69.3	69.3			139.4	139.4	74.2	148.4	28.9	28.9	7.7	7.7		
Chesapeake & Ohio Ry. of Indiana	269.0	269.0													38	24
Chicago & Alton			18.7	18.7			103.9	103.9					18.5	18.5	24	5
Chicago & Eastern Illinois	161.1	217.3	8.9	10.2			61.4	61.4							57	17
Chicago & North Western	1,801.7	1,812.5	722.9	827.4											434	262
Chicago & Western Indiana					9.5	22.2									19	
Chicago, Burlington & Quincy	4,923.5	4,923.5	2,500.4	3,141.5			1,214.8	1,214.8			53.3	53.3			1,148	762
Chicago Great Western	1,329.4	1,353.1											1.5	1.5	213	109
Chicago, Indianapolis & Louisville	525.0	525.0													71	44
Chicago, Milwaukee & St. Paul	3,793.9	4,232.7											13.1	13.1	629	273
Chicago, Milwaukee & Puget Sound			1,362.7	1,362.7									2.0	2.0	123	34
Chicago, Rock Island & Pacific			988.7	988.7									9.0	9.0	143	33
Chicago, St. Paul, Minneapolis & Omaha	190.2	190.2	465.8	529.9											119	53
Cincinnati, Hamilton & Dayton	33.9	47.8													10	
Cincinnati, Indianapolis & Western	99.0	99.0													20	10
Colorado Midland													2.0	2.0	2	
Cornwall & Lebanon	22.0	35.7													7	7
Cumberland & Pennsylvania	7.3	13.3													6	3
Cumberland Valley	17.6	17.6	17.6	17.6			2.0	2.0							12	
Delaware, Lackawanna & Western											1.5	1.5	4.3	4.3	4	
Duluth & Iron Range			16.2	17.6											9	6
Durham & Southern	56.0	56.0	56.0	56.0											9	
Elgin, Joliet & Eastern	11.3	11.3													2	
Erie	404.7	659.2	143.4	259.3	427.7	589.6									302	74
Chicago & Erie	248.8	257.2													60	8
Columbus & Erie	22.4	32.2													3	3
New Jersey & New York					26.1	26.1									11	5
New York, Susquehanna & Western	34.7	53.4													14	5
Evansville & Terre Haute			108.5	108.5											21	1
Great Northern							239.8	239.8					18.7	18.7	57	1
Hocking Valley	144.0	144.0													40	
Illinois Central					7.0	12.0	7.0	12.0					7.0	7.0	8	
Illinois Traction													24.0	24.0		
Iowa Central	11.0	11.0													3	
Kanawha & Michigan							1.3	1.3							2	
Kansas City, Clinton & Springfield			2.5	2.5											2	
Kentucky & Indiana Bridge & R. R. Co.	11.1	17.9													8	
Kentwood & Eastern			3.3	3.3											2	2
Lackawanna & Wyoming Valley			1.2	2.4									2.2	3.4	3	2
Lehigh Valley	697.0	759.4											17.3	17.3	162	118
Long Island [2]					14.1	28.2			8.6	17.2					37	10
Louisville & Nashville	438.2	541.8	57.7	57.7											103	10
Marquette & Southeastern	3.7	3.7													2	2
Minneapolis, St. Paul & Sault Ste. Marie	2,396.3	2,400.7	54.9	54.9											242	192
Missouri, Kansas & Texas	8.6	8.6													3	1
Missouri Pacific			7.0	14.0			1.9	1.9			1.2	1.2	8.5	8.5	8	1
St. Louis, Iron Mountain & Southern	5.2	5.2	2.8	4.4									4.7	4.7	10	
Mobile & Ohio	47.8	47.8													10	3
Nashville, Chattanooga & St. Louis	95.5	107.3									9.1	9.1			42	
Newburgh & South Shore							6.2	11.4							4	4
New York Central Lines:																
Boston & Albany							1.9	3.7							39	1
Chicago, Indiana & Southern	203.7	263.6													21	17
Cleveland, Cincinnati, Chicago & St. Louis	572.6	760.4	351.9	526.4											209	25
Lake Erie & Western	871.9	880.9	571.4	580.4											153	112
Lake Shore & Michigan Southern	967.9	1,039.1	88.2	88.9											216	110
Dunkirk, Allegheny Valley & Pittsburgh	90.5	90.5													19	17
Lake Erie, Alliance & Wheeling			87.7	87.7											22	16
Michigan Central	920.3	939.7													140	74
New York Central & Hudson River	2,151.2	2,685.8							169.1	338.1	290.1	586.5			639	288
Peoria & Eastern	86.5	89.0													24	11
Pittsburg & Lake Erie							22.7	25.6							15	9
New York, New Haven & Hartford	201.3	254.6							227.2	606.0	1.0	2.0	6.3	6.3	163	38
Norfolk & Western	1,010.1	1,058.6	281.3	318.5											214	120
Northern Pacific [1]	587.2	735.2	510.6	647.9									1.3	1.3	191	14
Northwestern Pacific	199.2	199.2	51.3	51.3											35	29
Pennsylvania	1,147.4	1,799.8	1,198.3	1,948.7	.8	1.6					14.7	17.1			650	100
Cleveland, Akron & Columbus	143.9	161.3													33	
Cincinnati & Muskingum Valley	11.4	11.4													3	
Grand Rapids & Indiana	55.8	55.8	2.2	4.4											15	4
Northern Central	366.2	546.1	60.8	61.8							.7	1.4			54	11
Pennsylvania Company	736.5	1,066.4	12.6	18.1											198	3
Philadelphia, Baltimore & Washington	238.7	391.6	95.2	169.4											97	13
Pittsburg, Cincinnati, Chicago & St. Louis	1,085.5	1,772.8	8.1	15.8							8.5	8.5			288	11
West Jersey & Seashore			79.6	112.6							.5	.5			24	14
Vandalia	355.9	416.8									6.0	6.0			88	8
Peoria & Pekin Union	6.0	12.0													3	
Pere Marquette	39.0	39.0													8	1
Philadelphia & Reading	236.9	333.5	.7	.7							1.1	1.1	1.8	2.1	92	29
Atlantic City [5]	35.7	35.7	13.1	13.1											14	12
Northeast Pennsylvania													1.6	1.6	2	2
Perkiomen	38.1	38.1													12	8
Reading & Columbia	35.9	35.9													12	12
Queen & Crescent Route.																
Cincinnati, New Orleans & Texas Pacific													.7	.7	2	
Quincy, Omaha & Kansas City and Iowa & St. Louis	305.0	305.0													47	38
Richmond, Fredericksburg & Potomac	9.0	9.0	78.7	157.4											19	3
St. Joseph & Grand Island					.3	.3									1	
St. Louis & San Francisco			140.7	140.7									16.6	16.6	32	13
Beaumont, Sour Lake & Western	84.7	84.7													5	3
New Orleans, Texas & Mexico	157.6	157.6													11	11
Orange & Northwestern	61.6	61.6													5	5

[1] (Atchison, Topeka & Santa Fe: Western lines.) These figures include 18.7 miles of double-track road on which the electric train staff is used for trains moving in one direction (down grade), and the simple manual block system, by means of the telephone, for trains moving in the opposite direction.

[2] (Long Island; Atlantic Coast Line.) A number of these offices are closed several months during the year.

[3] (Central New England.) The 1.3 miles on which the electric train staff system is used is worked jointly with the Poughkeepsie City & Wappingers Falls Electric Ry.

[1] (Northern Pacific.) Both the telegraph and the telephone are used in connection with the block system on 105.6 miles of road.

[5] (Atlantic City.) Both the telegraph and the telephone are used in connection with the block system on 13.1 miles of single track.

METHODS AND APPARATUS USED WITH MANUAL BLOCK SYSTEM—Continued

Names of railroads.	Telegraph.		Telephone.		Electric bells.		Controlled manual. No track circuit.		Controlled manual. Track circuit at stations.		Controlled manual. Continuous track circuit.		Electric train staff.		Block signal stations.	
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Total number.	Number closed part time.
St. Louis Merchants' Bridge Terminal	1.1	2.2													3	
Seaboard Air Line			206 6	206.6									6.9	6.9	46	16
Southern	1,819.6	2,066.9	10.1	10.1									5.9	5.9	381	137
Southern Pacific, Pacific System													98.0	98.0	38	
Spokane, Portland & Seattle	10.0	20.0													6	
Staten Island	12.7	22.8													6	2
Terminal R. R. Association of St. Louis	1.1	2.2													2	
Tidewater Power Co.[3]													6.2	6.2	2	
Toledo, Peoria & Western				.3	.3										2	
Toledo, St. Louis & Western	188.0	188.0													28	15
Union							.5	.5			.9	.9			2	
Union Pacific													11.4	11.4	6	
Virginia & Kentucky			.6	.6											1	
Virginian			2.2	2.2											2	
Wabash	1,820.7	1,914.7													269	116
Washington Southern			32.2	64.4											9	
Total	38,612.7	44,541.9	12,198.8	15,038.1	485.8	680.0	1,802.8	1,817.7	483.9	1,119.3	439.4	739.9	345.6	347.1	9,912	3,751

[3] (Tidewater Power Co.) Staff system without electric control.

PRACTICES IN THE OPERATION OF THE MANUAL BLOCK SYSTEM

Names of railroads.	Automatic block signals. Single track.	Automatic. Double track.	Automatic. Three track.	Automatic. Four track.	Automatic. Total. Miles of road.	Automatic. Total. Miles of track.	Nonautomatic block signals. Single track.	Nonautomatic. Double track.	Nonautomatic. Three track.	Nonautomatic. Four track.	Nonautomatic. Total. Miles of road.	Nonautomatic. Total. Miles of track.	Total automatic and nonautomatic. Miles of road.	Total automatic and nonautomatic. Miles of track.	Total passenger lines operated. Miles of road.	Total passenger lines operated. Miles of track.	Percentage block-signaled (miles of track).
Ann Arbor							1.4				1.4	1.4	1.4	1.4	291.9	291.9	0.4
Atchison, Topeka & Santa Fe:[1]																	
Eastern lines	5.7	73.6			79.3	152.9	361.4	475.3	12.9		849.6	1,350.7	928.9	1,503.6	2,519.0	3,097.1	48.5
Western lines	33.4	2.4			35.8	38.2	541.8	23.9			565.7	589.6	601.5	627.8	2,797.8	2,824.1	22.2
Coast lines	18.9	1.0			19.9	20.9	4.3				4.3	.4.3	24.2	25.2	1,825.5	1,872.3	1.3
Gulf, Colorado & Santa Fe	10.8				10.8	10.8	2.1				2.1	2.1	12.9	12.9	1,540.0	1,540.0	.8
Atlantic Coast Line	3.1	12.1			15.2	27.3	373.1	101.7			474.8	576.5	490.0	603.8	3,832.4	3,957.9	15.1
Auburn & Northern	6.5				6.5	6.5							6.5	6.5	6.5	6.5	100.0
Baltimore & Ohio	15.2	198.3		4.6	218.1	430.1	363.6	580.4	87.0	15.7	1,046.7	1,847.9	1,264.8	2,278.0	3,140.5	4,205.1	54.2
Baltimore & Ohio Chicago Terminal	.8	10.0			10.8	20.8							10.8	20.8	45.8	73.0	28.5
Baltimore & Ohio Southwestern		14.0			14.0	28.0	922.8	35.0		2.2	960.0	1,001.9	974.0	1,029.9	980.1	1,039.7	99.0
Baltimore & Sparrow's Point							1.7	3.0			4.7	7.7	4.7	7.7	4.7	7.7	100.0
Bessemer & Lake Erie[2]							64.4	130.3			194.7	325.1	194.7	325.1	191.8	322.2	96.9
Boston & Maine	124.7	570.3		2.1	697.1	1,273.7		4.8			4.8	9.6	701.9	1,283.3	2,238.6	2,801.6	45.8
Boston, Revere Beach & Lynn		13.8			13.8	27.6							13.8	27.6	13.8	27.6	100.0
Buffalo, Rochester & Pittsburg							301.2	128.7			429.9	558.7	429.9	558.7	429.9	558.7	100.0
Butte, Anaconda & Pacific	7.9				7.9	7.9							7.9	7.9	25.3	25.3	31.2
Central New England							16.0				16.0	16.0	16.0	16.0	275.0	296.9	5.7
Central of Georgia							52.3	7.4			59.7	67.1	59.7	67.1	1,915.9	1,915.9	3.5
Central of New Jersey	13.0	165.5	2.4	31.5	212.4	477.2							212.4	477.2	464.1	742.9	64.2
Chesapeake & Ohio[3]		183.0			183.0	366.0	1,274.2	125.9			1,400.1	1,526.0	1,583.1	1,892.0	1,607.4	1,916.3	98.7
Chesapeake & Ohio Ry. of Indiana							269.0				269.0	269.0	269.0	269.0	269.0	269.0	100.0
Chicago & Alton	416.1	144.9			561.0	705.9	141.2				141.2	141.2	702.2	847.1	998.9	1,143.0	74.1
Chicago & Eastern Illinois		98.4			98.4	196.8	173.9	57.5			231.4	288.9	329.8	485.7	693.0	849.5	57.2
Chicago & North Western		719.6	13.8	6.0	739.4	1,504.6	2,409.3	115.3			2,524.6	2,639.9	3,264.0	4,144.5	6,894.0	7,806.0	53.1
Chicago & Western Indiana		17.8			17.8	35.6		6.3	3.2		9.5	22.2	27.3	57.8	27.3	57.8	100.0
Chicago, Burlington & Quincy		35.4	1.6	5.4	42.4	97.2	8,070.8	602.7	17.1	1.4	8,692.0	9,333.1	8,734.8	9,430.3	8,421.5	9,171.2	100.0
Chicago Great Western	61.0	64.9			125.9	190.8	1,307.2	23.7			1,330.9	1,354.6	1,456.4	1,545.4	1,472.2	1,568.4	98.5
Chicago, Indianapolis & Louisville							525.0				525.0	525.0	525.0	525.0	579.1	579.1	90.6
Chicago, Milwaukee & St. Paul	5.9	103.7			109.6	213.3	3,368.2	438.8			3,807.0	4,245.8	3,916.6	4,459.1	7,511.6	8,081.5	55.2
Chicago, Milwaukee & Puget Sound							1,364.7				1,364.7	1,364.7	1,364.7	1,364.7	1,364.7	1,364.7	100.0
Chicago, Peoria & St. Louis Ry. of Illinois	1.3				1.3	1.3							1.3	1.3	226.9	226.9	.6
Chicago, Rock Island & Pacific	653.3	279.6			932.9	1,212.5	997.7				997.7	997.7	1,930.6	2,210.2	6,682.7	6,974.4	31.6
Chicago, Rock Island & Gulf	32.6				32.6	32.6							32.6	32.6	468.9	468.9	6.9
Chicago, St. Paul, Minneapolis & Omaha		6.2			6.2	12.4	591.9	64.1			656.0	720.1	662.2	732.4	1,468.1	1,553.4	47.2
Cincinnati, Hamilton & Dayton	20.0	14.3			34.3	48.6	20.0	13.9			33.9	47.8	68.2	96.4	527.9	563.4	17.1
Cincinnati, Indianapolis & Western							99.0				99.0	99.0	99.0	99.0	360.9	360.9	27.2
Colorado Midland							2.0				2.0	2.0	2.0	2.0	258.4	258.4	.8
Cornwall & Lebanon							8.3	13.7			22.0	35.7	22.0	35.7	22.0	35.7	100.0
Cumberland & Pennsylvania							4.3		3.0		7.3	13.3	7.3	13.3	31.3	34.8	38.2
Cumberland Valley		6.7			6.7	13.4	19.6				19.6	19.6	26.3	33.0	162.2	207.0	15.9
Delaware & Hudson	163.1	225.1	4.3	17.5	410.0	696.3							410.0	696.3	743.9	1,042.4	55.1
Delaware, Lackawanna & Western	104.7	435.1	38.3	6.6	584.7	1,116.3	5.8				5.8	5.8	590.5	1,122.1	922.1	1,465.9	76.5
Duluth & Iron Range							14.8	1.4			16.2	17.6	16.2	17.6	168.0	240.0	7.3
Durham & Southern							56.0				56.0	56.0	56.0	56.0	56.0	56.0	100.0
Elgin, Joliet & Eastern	2.0	3.0			5.0	8.0	11.3				11.3	11.3	16.3	19.3	223.9	281.6	6.8
Erie		212.2		14.9	227.1	484.0	643.5	432.3			1,075.8	1,508.1	1,302.9	1,992.1	1,706.5	2,395.7	83.1
Chicago & Erie							240.4	8.4			248.8	257.2	248.8	257.2	248.8	257.2	100.0
Columbus & Erie							12.6	9.8			22.4	32.2	22.4	32.2	22.4	32.2	100.0
Erie & Jersey		42.3			42.3	84.6							42.3	84.6	Freight line.		
New Jersey & New York		10.5			10.5	21.0	26.1				26.1	26.1	36.6	47.1	51.8	61.3	76.6
New York, Susquehanna & Western							16.0	18.7			34.7	53.4	34.7	53.4	208.4	227.1	23.5
Evansville & Terre Haute							105.8				105.8	105.8	105.8	105.8	143.3	143.3	73.8
Grand Trunk	1.1	1.6			2.7	4.3							2.7	4.3	686.6	1,014.9	.4
Great Northern	8.5	122.3			130.8	253.1	258.5				258.5	258.5	389.3	511.6	7,020.4	7,142.7	7.2
Hocking Valley							144.0				144.0	144.0	144.0	144.0	336.6	375.5	38.3
Hudson & Manhattan[4]		7.3			7.3	15.6							7.3	15.6	7.3	15.6	100.0
Illinois Central[5]	65.1	235.1		12.0	312.2	620.9	9.0	5.0			14.0	19.0	326.2	639.9	4,462.7	5,027.2	12.7
Yazoo & Mississippi Valley	6.6				6.6	6.6							6.6	6.6	1,193.0	1,200.7	.6

[1] (Atchison, Topeka & Santa Fe.) On this road automatic signals are used to protect short sections of track in manual block territory, aggregating 80.7 miles of track.
[2] (Bessemer & Lake Erie.) These figures include 8.9 miles of road on which no passenger trains are run.
[3] (Chesapeake & Ohio.) Includes Coal River.
[4] (Hudson & Manhattan.) Light signals, not shown in Table 2.
[5] (Illinois Central; New York, New Haven & Hartford; Pennsylvania; Washington Terminal.) Include road with more than 4 tracks.

PRACTICES IN THE OPERATION OF THE MANUAL BLOCK SYSTEM — Continued

Names of railroads.	Permissive signaling forbidden.		Permissive signaling allowed. By three-position signal.		Permissive signaling allowed. By two-position signal and flag or lantern.		Permissive signaling allowed. By caution card.		Rear-end protection only.		Stop at station recognized as stop for signal opposite office.	
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.
Pennsylvania	172.7	381.1	[1,2] 2,131.5	3,202.1	157.3	185.8	33.8	48.6				
Cleveland, Akron & Columbus			[1,2] 143.9	161.3							143.9	161.3
Cincinnati & Muskingum Valley			[1,2] 11.4	11.4							11.4	11.4
Grand Rapids & Indiana	2.2	4.4	55.8	55.8							55.8	55.8
Northern Central	15.3	21.2	[1,2] 152.4	278.8								
Pennsylvania Company			[1,2] 749.1	1,084.5							749.1	1,084.5
Philadelphia, Baltimore & Washington			[1,2] 333.9	561.0								
Pittsburg, Cincinnati, Chicago & St. Louis			[1,2] 1,102.1	1,797.1							1,102.1	1,797.1
West Jersey & Seashore							[2] 80.1	113.1				
Vandalia	6.0	6.0	[1,2] 355.9	416.8							355.9	416.8
Peoria & Pekin Union			[2] 6.0	12.0								
Pere Marquette	39.0	39.0									39.0	39.0
Philadelphia & Reading	28.8	47.5					[1,2] 211.7	289.9				
Atlantic City	35.7	35.7										
Northeast Pennsylvania	1.6	1.6										
Perkiomen							[1,2] 38.1	38.1				
Reading & Columbia							[1,2] 35.9	35.9				
Queen & Crescent Route:												
Cincinnati, New Orleans & Texas Pacific							[2] .7	.7				
Quincy, Omaha & Kansas City and Iowa & St. Louis							305.0	305.0	305.0	305.0	305.0	305.0
Richmond, Fredericksburg & Potomac							[1,2] 87.7	166.4				
St. Joseph & Grand Island			[2] .3	.3								
St. Louis & San Francisco	157.3	157.3										
Beaumont, Sour Lake & Western					[2] 84.7	84.7						
New Orleans, Texas & Mexico					[2] 157.6	157.6						
Orange & Northwestern					[2] 61.6	61.6						
St. Louis Merchants' Bridge Terminal			1.1	2.2								
Seaboard Air Line	6.9	6.9					[3] 206.6	206.6				
Southern	10.1	10.1					[3] 1,819.6	2,066.9				
Southern Pacific—Pacific System	98.0	98.0										
Spokane, Portland & Seattle									10.0	20.0	10.0	20.0
Staten Island			[1] 12.7	22.8			[1] 12.7	22.8			12.7	22.8
Terminal R. R. Ass'n of St. Louis			1.1	2.2								
Toledo, St. Louis & Western							[2] 188.0	188.0				
Toledo, Peoria & Western	.3	.3										
Union	1.4	1.4										
Union Pacific	.5	.5					10.9	10.9				
Virginia & Kentucky	.6	.6										
Virginian	2.2	2.2										
Wabash							1,820.7	1,914.7	769.1	769.1		
Total	6,526.4	8,378.2	23,323.0	28,498.7	1,674.6	1,972.3	23,471.5	25,856.9	11,455.4	11,641.3	23,579.4	26,878.7

[1] Permissive signaling is practiced only in the case of a freight train following a freight train, or in similar movements where neither train carries passengers.
[2] By dispatcher.
[3] By rule.

WIRE-CIRCUIT BLOCK SIGNAL SYSTEMS ON ELECTRIC INTERURBAN RAILWAYS

Names of companies.	Miles of road equipped.	Names of companies.	Miles of road equipped.
Boston & Northern	63.8	New Hampshire electric railways—Continued.	
Old Colony	172.7	Haverhill & South New Hampshire	7.8
Boston & Worcester	7.1	Haverhill, Plaistow & Newton	8.1
Cincinnati, Lawrenceburg & Aurora	26.6	Hudson, Pelham & Salem	26.9
City & Suburban Railway of Washington	9.0	Lawrence & Methuen	12.5
Connecticut	12.8	Lowell & Pelham	3.1
Delaware County & Philadelphia	14.8	Portland Railway Light & Power	14.4
Detroit, Monroe & Toledo	.3	Toledo, Ottawa Beach & Northern	11.2
New Hampshire electric railways:		Trenton, Bristol & Philadelphia	16.7
Amesbury & Hampton	8.3	Western New York & Pennsylvania Traction	85.4
Haverhill & Amesbury	25.9		
Haverhill & Plaistow	2.7	Total	530.1

DICTIONARY OF
WORDS, TERMS AND PHRASES USED IN

RAILWAY SIGNALING

Page and Figure Numbers in the Dictionary Refer to the Section of Descriptions and Illustrations.

A

A. C. Abbreviation for Alternating Current.

A. R. A. Abbreviation for American Railway Association.

Absolute Block Signaling. The rigid adherence to the fundamental principle of the block system that no train be admitted to a block while another train occupies it. See **Permissive Block Signaling.**

Accumulator. A word sometimes applied to a current accumulator or storage battery. See Figs. 2250-2264.

Active Current. A working component of a current in an alternating current circuit as distinguished from a wattless component of current. The component of an alternating current which is in phase with the impressed electromotive force.

Adjustable Crank. See Figs. 1172-1173.

Adjustable Lock Rod. See Figs. 1522-1527.

Adjusting Screw. A device in a pipe or wire line used for changing its length, as in case of wires subject to expansion and contraction due to changes of temperature. See Figs. 1026-1046, 1307-1308.

Admittance. The reciprocal of the impedance in an alternating current circuit. The apparent conductance of an alternating current circuit or conductor.

Advance (adjective). In an advanced position, as a signal, as related to the train for which such signal is used. A train approaching a station which has a distant, a home, and an advance signal, encounters first the distant, then the home, and then the advance. The distant is in the rear of the home, and the home is in the rear of the advance signal.

Advance Block Signal. A fixed signal used in connection with the home block signal to subdivide the block in advance.

Function. To govern movements of all trains on main tracks, and of all trains moving from sidings to main tracks between home and advance block signals into block ahead. To provide for closing in trains.

Location. Governed by consideration of consistent and convenient operation. If the advance block signal is located close ahead of the trailing switch of a passing siding, the front end of a long train must pass this signal in order to back in on the siding. If an unlock has been received it would then be taken up unless a special circuit arrangement were provided to prevent it. If the unlock has been taken up the following train must be carded. If the engine and first part of a train are permitted to pass an advance block signal indicating stop, when making such a switching movement, the absolute stop indication of the signal is violated, introducing an inconsistency in the operation. If the advance block signal is located a sufficient distance ahead of the trailing switch nearest to it, so a train backing in will not have to pass the signal, its location will be in some cases 3,500 ft. from the block station, and if the signal fails to clear after the train reaches it, or after the train has passed the home signal, serious delay results.

Advance Signal. A signal having the same function as a home signal, placed some distance in advance of the home signal at a block or interlocking signal station, providing in effect a short block section in which the signalman may hold a train while not interfering with the movement of trains in the main block section, either in advance or in the rear. He can accept another train in the rear block as soon as the arriving train has passed completely beyond his home signal, and he can hold the arriving train at the advance signal until the block in advance is clear. In Great Britain a signalman is forbidden, except under rigid restrictions, to authorize a train to proceed toward his station from the station in the rear, unless the last preceding train has passed beyond his starting signal; or, if there is no such signal, until it has passed 1,320 ft. (¼ mile) beyond his home signal. The restriction is that he must give to the rear station a special authorization, "section clear, but station or junction blocked," and this information must be given to the engineman by word of mouth. See Figs. 314, 318, 766-769, 787.

Advance Starting Signal. (British.) See **Starting Signal.**

Air Gap. The space between the ends of the poles of an electro-magnet and the armature of the magnet. Any break occupied wholly by air in a magnetic circuit.

Alligator Jaw. See **Escapement Crank.**

"All Right." An oral signal commonly given by a conductor to an engineman, meaning proceed to the next station or regular stopping place; used also, loosely, in speaking of the "proceed" indication of a fixed signal. In British practice the oral signal, "right away," has a meaning similar to the American "all right."

Alternating Current. A current of electricity which flows alternately in opposite directions, its magnitude varying from maximum in one direction through zero to maximum in the opposite direction and back again according to the laws of simple harmonic motion, as distinguished from continuous or **Direct Current,** which see. A complete change from any value to the corresponding value in the opposite direction and back again is called an alternation or cycle, and the number of such alternations in a second is called the

frequency of the current. In commercial applications frequency usually varies between 25 and 120 cycles per second. Two alternating currents equal in magnitude and frequency may not attain equal values simultaneously. The interval between the assuming of a given value by one current and of the same value by the other current is called the phase difference between the two. It is usually spoken of in terms of the angular difference between the rotating parts generating the two currents. Referred to a given current, another current which passes through stated values ahead of the reference current is said to lead, and one which reaches these values after the reference current is said to lag. A single alternating current consists of two single phase currents flowing in opposite directions at a given instant, a three-phase current consists of three currents a third of a cycle apart, four-phase, four currents a quarter of a cycle apart, and so on for any number of phases. The value of an alternating current, which is commonly used in referring to it, is not the maximum value it reaches, but a value equal in magnitude to that of a direct current which would produce the same heating effect. This value is $\frac{1}{\sqrt{2}}$ or .707 times the maximum value.

Alternating Current Relay. A relay designed to respond to alternating current. See Figs. 608-609, 680-684, 696, 3087, 3103.

Alternation. A change in direction. A change or reversal in the direction of an electromotive force or current. A single vibration or oscillation as distinguished from a complete cycle or double vibration.

Alternator, or Alternating Current Generator. One which produces alternating currents, either single-phase or polyphase.

American Wire Gauge. The name generally given to the Brown and Sharpe wire gauge, in which the largest wire, No. 0000, has a diameter of .46 in., the smallest wire, No. 36, .005 in., and all other diameters are in geometrical progression.

Ammeter. An instrument for measuring in terms of amperes, the current flowing in an electrical circuit. It consists of a fixed coil of heavy wire carrying the current to be measured and a pivoted magnetic core, to which is attached a pointer sweeping over a fixed scale. The force tending to displace this core from its normal position varies with the current passing through the coil and is resisted by some opposing force (usually gravity, a spring, or a powerful permanent magnet), which brings the pointer into a new position of equilibrium for each value of the current. See Figs. 3515, 3520, 3523, 3525, 3526, 3528, 3529, 3534.

Ampere. The practical unit of measurement of electric current or the rate of flow. Such a current as will pass with an electromotive force of one volt through a circuit of one ohm resistance. The analogy of water flowing through a pipe will make this clear. That which causes the water to flow is the pressure or head; that which resists the flow is the friction of the water against the pipe, and the rate of flow may be represented by so many cubic inches of water per second. Electrically, the pressure corresponds to electromotive force, the friction to resistance and the quantity per second or the number of amperes to the rate of flow. As the pressure increases the flow increases proportionally; as the resistance increases the flow decreases. The relation between amperes, volts and ohms is represented by Ohm's law, $I = \frac{E}{R}$, in which I is the current, R the resistance and E the electromotive force. The standard of measurement for an ampere is such a current as will deposit 4.024 grammes of silver in one hour on one of the plates of a silver volt-ammeter from a solution of silver nitrate containing from 15 to 30 per cent of the salt.

Ampere-hour. A unit of electrical quantity equal to the quantity of electricity conveyed by one ampere flowing for one hour. A quantity of electricity equal to 3,600 coulombs.

Ampere-hour Meter. An instrument giving the total time integral of the amperes.

Ampere Turn. A unit of magneto-motive force equal to that produced by one ampere flowing around a single turn of wire.

Angle Bar. A term used to denote a common form of fastening used to connect together and hold in line the ends of two rails which, placed end to end, form a part of a railway track. A modification of the fish bar, or fish plate.

Angle Cock. In an automatic air-brake system, the stopcock, one at each end of each car, by which, when a car is to be detached from the train, the compressed air in the train pipe of that car is confined. The undesired automatic application of the brakes is thereby prevented. In a train made up for operation every angle cock except that at the extreme rear of the train and that at the front of the engine must be open. The accidental closing of such a cock, by cutting off the engineman's control of the brakes in that part of the train in the rear of the closed cock, may cause disaster.

Angle of Lag. The angular difference in position of a point on a curve representing values of an alternating current behind the corresponding point on a curve representing other values of the same current or the same values of another current. An angle whose tangent is equal to the ratio of the inductive to the ohmic resistance and whose cosine is equal to the ratio of the ohmic resistance to the impedance in the alternating current circuit.

Angle of Lead. The angular difference in position of a point on a curve representing values of an alternating current ahead of the corresponding point on a curve representing other values of the same current or the same values of another current. Opposed to angle of lag, which see.

Anion. The electro-negative ion or radical of a molecule.

Annunciator. A device, audible or visual, to announce the approach of a train. Visual annunciators are either of the drop type or of the same general form and appearance as indicators; see Figs. 2550-2629. Audible annunciators are usually electric bells. See **Approach Indicator.**

Anode. The conductor or plate of a decomposition cell connected with the positive terminal of a battery or other electric source. The terminal of an electric source out of which the current flows into the electrolyte of a decomposing cell, or volt-ammeter. In an electrolyte cell, bath, or receptive

device, the terminal at which the current enters, as distinguished from the cathode, at which the current leaves.

Answer Back. A circuit-interrupting device used with electric selectors or signals in a selective telephone or telegraph train dispatching or signal system, so arranged as to indicate over the telephone or telegraph circuit to the dispatcher the operation of the bell or signal at the desired station. See pages 126-132.

Apparent Efficiency. The efficiency of a generator, motor, or other apparatus in an alternating current circuit which equals the ratio of net power output to volt-ampere input.

Apparent Electromotive Force. The E.M.F. apparently acting in a circuit as measured by the drop of pressure due to the resistance of the circuit and the current strength passing through it.

Apparent Power. In an alternating current circuit, the apparent watts, or the product obtained by multiplying the volts by the amperes, as read directly from a voltmeter and ammeter.

Apparent Resistance. The impedance of an alternating current circuit containing both resistance and reactance. The quotient obtained from dividing voltage by current in such a circuit.

Approach Indicator. A block indicator for an approach locking or other track circuit.

Approach Locking. Electric locking effected by the approach of a train, the train actuating a track-circuit relay or a track instrument. The arrangement is such that the levers are locked as soon as a train approaches the signals; that is, while it is yet some distance away, as one or two miles. If an approaching train by this means locks switches and then is stopped and detained and does not use the route, the signalman can unlock his levers by closing the unlocking circuit by means of a "time release." The releasing device is arranged to enforce deliberation (and thus prevent errors) by an automatic time device; by a slow-moving circuit closer operated by making a number of turns of a screw; or by a hand switch fixed in some inaccessible place, requiring some time for the signalman to get to it. Thus the signalman will be prevented from hastily taking away a route which has been set up for an approaching train. Approach locking may be used for only one or two movements through an interlocking, or it may be expanded to cover any possible movement. Typical approach locking circuits are shown and explained in Figs. 2055-2068, 2073. **See Screw Release, Lock, Electric, Time Release.**

Arm. The principal movable part of a semaphore, consisting of a blade of wood or metal, fastened to a casting, which turns on the supporting pivot. See Figs. 229, etc., and Figs. 3224-3478.

Arm Casting. That part of a semaphore arm which contains the bearing and the spectacles for holding the glasses which give the night color indications. To it is fastened the blade. See Figs. 3224-3478.

Armature. A mass of iron or other magnetizable material placed on or near the pole or poles of a magnet. In the case of a permanent magnet the armature may be of soft iron, placed directly on the magnetic poles, in which case it preserves or keeps the magnetism by closing the lines of magnetic force of the magnet through the soft iron of the armature. It is then called a keeper. In the case of an electromagnet the armature is placed near the poles and is moved toward them whenever the magnet is energized by the passage of the current through the magnetizing coils. This movement is made against the action of a spring or gravity, so that on the loss of magnetism by the magnets, the armature moves from the magnetic poles. When the armature is of soft iron it moves toward the magnet on the completion of the circuit through its coils, no matter in what direction the current flows, and is then called a non-polarized or neutral armature. When made of steel or of another electromagnet it moves from or toward the poles according to whether the poles of the armature are of the same or of a different polarity from those of the magnet. Such an armature is called a polarized armature (Houston). The term armature is applied to the rotor or stator of a motor or generator. See **Magnet.**

Arm Sweep. The segment of a circle defining the limits of the movement of a semaphore signal arm.

Asbestos. A hydrous silicate of magnesia, i. e., silicate of magnesia combined with water. A fireproofing material sometimes used by itself or in connection with other material for insulating purposes.

Automatic Block Signal. A block signal, worked by electric or pneumatic agency, which is controlled by the passage of a train into, through and out of the block section to which the signal is connected. The entrance of a train sets the home signal at stop, and the clearing of the block section by the passage of the train out of it sets that signal clear. The apparatus is so arranged that the misplacement of a switch or the accidental entrance of a car from a side track will set the signal at stop. See **Track Circuit, Distant Signal.**

Automatic Block Signal System. A series of consecutive blocks. Automatic block signals were invented and developed in America, the first installation being 16 miles of the Eastern Railroad of Massachusetts (now the Boston & Maine) equipped with automatic signals in 1871. These signals were controlled by **Track Instruments,** which see. In 1879 the **Track Circuit,** which see, was introduced as a method of control on 10 miles of the Fitchburg Railroad, and is now universally used in automatic signaling.

Automatic Circuit-Breaker. A device for automatically opening a circuit when the current passing through it is excessive.

Automatic Stop. An apparatus, mechanical or electromagnetic, for stopping trains by means actuated from outside the train (as at a signal post). In the simplest form a trip, fixed on the roadway and moving in unison with the usual visual signal, is made to open an air valve on the engine, or car, thereby applying the power brakes or shutting off the propelling power, or both, independently of the engineman or motorman. See Figs. 653, 658, 667, 668, 669, 675, 686-688, 701, 703-709, 3691-3700.

Average Efficiency of Motor. The efficiency of an electric motor based on its average or mean load. The ratio of all the work that a motor delivers in a

given time to the electric energy it has absorbed in that time.

B

B. & S. Abbreviation for Brown & Sharpe's wire gauge.

B. W. G. Abbreviation for Birmingham wire gauge.

Back Contact. (Of a relay.) An electric contact which is made by the armature of a relay when it falls away from the pole piece of the magnet coils consequent on the cessation of the current flowing through the coils. See **Relay** and **Front Contact.**

Back Electromotive Force. A term sometimes used for counter electromotive force.

Back Light. A small glass-covered opening in the back of a signal lamp. It is to enable the signalman to keep watch of the light and be assured that it is always burning. The back light (spectacle) on the semaphore arm, usually carries a purple glass, so arranged that when the signal is at stop the back light shows purple, and when it is not in that position the back light shows white.

Back Locking. The mechanical locking in a "Standard" interlocking machine, which acts in the same plane as the tappets. See Figs. 851-902.

Back Spectacle. A small casting containing a roundel at one end and fastened at the other to the semaphore shaft of a signal in such a manner as to change the visible color of the back light, which see, by passing before it. Sometimes instead of carrying a roundel the back spectacle is solid or carries a disk of metal to obscure the back light. See Figs. 3472-3476.

Back Wire. The wire connected to the back tail lever of an interlocking machine to pull a signal to the stop position. Used to insure that the movements of the signal arm shall follow the movements of the lever. Sometimes, especially in Europe, only one wire (the pulling wire, which see) is used.

Balance Lever. The lever which carries the signal counterweight. See 19-19A, and 26, Figs. 1639-1646, and 14, Figs. 1672-1675.

Balanced Circuit. A telephonic, telegraphic or other circuit which has been so erected and adjusted as to be free from mutual inductive disturbances from neighboring circuits.

Balancing Relay. A differentially wound relay.

Banjo Signal. A common name for the **Enclosed Disk Signal,** which see. So called because in general appearance it resembles a huge banjo.

Banner Signal. A common name for the **Clockwork Signal,** which see.

Basket. A term sometimes applied to a **Switch Adjustment,** which see.

Basket Rod. A term sometimes applied to a **Throw Rod,** which see.

Battery. A source of electricity. See **Primary Battery; Storage Battery.** See Figs. 2243-2351.

Battery Chute. A small receptacle for batteries, designed to be set in the ground below frost level in order to prevent freezing of the battery. Chutes are usually circular or oval and may hold one or two tiers of batteries. They are commonly made of cast iron and sometimes of reinforced concrete or fibre. See also **Well and Vault.** See Figs. 2370-2387, 2394-2399.

Battery Jar. A jar provided for holding the electrolyte of each of the separate cells of a primary or secondary battery. See Figs. 2256-2261, 2276, 2278, 2281-2283, 2323-2325, 2329, 2330-2334, 2337-2349.

Bell Code. A code in which are set forth the number of strokes of an electric bell to be sounded to give each of the necessary station-to-station communications in manual block signaling. See **Manual Block System.**

Bell Crank. See **Crank.**

Bell, Electric. A bell actuated by electromagnets. Used for long-distance communication and to announce trains either at a cabin or a highway crossing. See **Manual Block System, Controlled Manual Block System, Highway Crossing Signal, Telegraph Block System.** See Figs. 2146-2231.

Binding Post. A terminal of metal to which a wire may be attached to make an electric connection. The wire is usually clamped in place by a set of nuts screwed to a threaded projection on the post, or is inserted in a hole and held in place by a screw entering the post at right angles to the wire hole. See Fig. 2358.

Bipolar. Having two poles.

Blade. A signal arm consists of a spectacle casting and a blade. The blade may be of wood or metal and is of various shapes and painted with various stripes to indicate the function of the signal, as distant, home, interlocking or automatic. The blade is the extended part of the arm which gives the day indications. See Figs. 225-228, 3341-3343, 3361-3369.

Blade-Grip. That part of a semaphore arm or spectacle which is formed to receive the blade and to which the blade is fastened.

Blind Siding. A familiar term for a side track situated at a place where there is no station agent and no telegraph office.

Block (noun). A length of track of defined limits, the use of which by trains is governed by block signals. The common name for a block section.

Block Indicator. An electromagnetic device (in a signal cabin) controlled by a track circuit to indicate to the signal man whether or not that track circuit is occupied by a train. The electromagnet, actuated directly, or through a relay by the track circuit, has on its armature a miniature semaphore arm, the movements of which give the indications. See Figs. 2550-2629.

Block Instrument. The instrument used in controlled block signaling to compel the co-operation of the signalmen at both ends of the block in allowing a train to enter from either end. The arrangement is such that this can be done only when the block is clear. See Figs. 346-405.

Block Section. A section of track of defined length, the use of which by trains is regulated by a fixed signal at the entering end; or, on a single track line, by such signals at both ends. See Figs. 314-324.

Block Signal. A fixed signal at the entrance to a block section used to give indications regulating the movement of trains into that section. If there

is a switch immediately in advance of the signal it may be an interlocked signal also. See **Home Signal.**

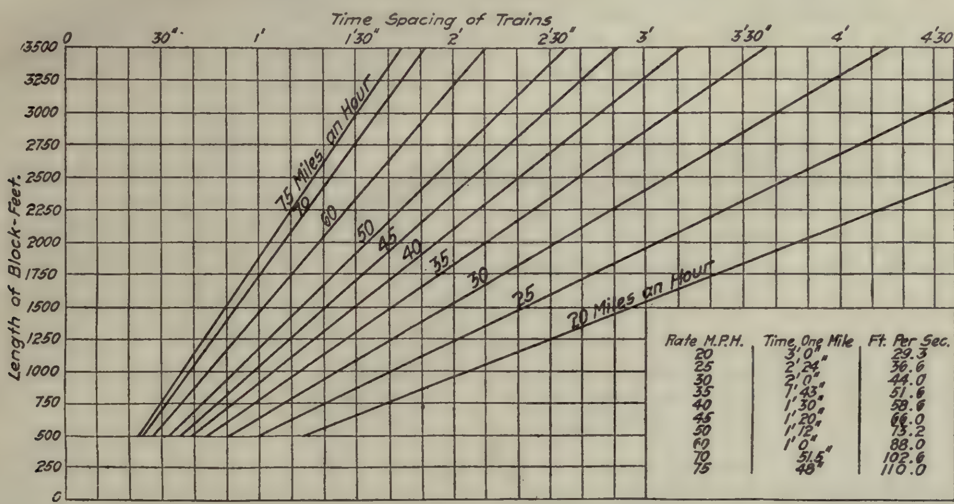
Block Signaling for Maximum Traffic. The conditions that determine the length of a block section and consequently the number of trains that may be run in a given time are:

(1) The speed.
(2) The braking power and consequent distance required in which to stop a train running at maximum speed.
(3) The grade of the track.
(4) The time required for the signals to change from the position indicating "Stop" to that indicating "Proceed."

home signal is the length of the shortest block that may be used with safety.

The speed of a train is affected by gravity assisting or retarding its motion according to the grade of the track. Any force affecting the speed of the train will have a corresponding effect on the braking power, and the length of the block must therefore be proportioned to the grade.

The length of time required for a signal to change from the stop to the proceed position has an important bearing on the efficiency of a signal system and the consequent spacing of trains. The time required for a signal to assume the clear position is only a few seconds; but, as the home signal does not commence to clear until the train has passed



(5) The length of the train.
(6) The position of interlocking plants, stations and other local conditions which cause an irregular spacing of the signals.

The number of trains that may be run in a given time is dependent on the speed. The greater the speed the greater the number of trains that may be run. To provide for a maximum train service it must be possible to run trains at the greatest speed local conditions permit, and the blocks must be of such length as to allow this speed to be attained with safety.

To run a train safely at a given speed it is necessary to keep the engineman informed, at all times, of the condition of the track in front of him and if it is proper for the train to proceed. If it is not safe to proceed the engineman must be warned at a point sufficiently far away from the stopping point to enable him to bring the train to a stop before passing it. The higher the speed the greater the distance from the stopping point the indication to stop or to proceed must be given.

The distant indication is given by the distant signal, and it is therefore necessary that this signal be placed far enough from the home signal to enable a train to be brought to a stop in the distance between the two signals. The braking power then becomes as important an element in determining the length of the block for a maximum train service under safe working conditions as are the factors of speed and grade. With good practice demanding that, as a regular thing, the indication of a home signal shall be repeated by one and not by two distant signals, it follows that for the average conditions the distance between the distant and the

out of the block, the next following train is delayed, while the home and the distant signals are clearing. The practical result is the same as if the block had been lengthened the distance the train will run in the time the two signals are clearing. A maximum train service requires a minimum time for the clearing of the signals. A change from one second to five seconds in the time required to clear a signal—lengthening the time four seconds—will reduce by 10 per cent the number of trains it is possible to run when the speed is 60 miles an hour and the length of block equal to the braking distance.

The length of a train will affect the number it is possible to run in a given time, for the signals do not commence to clear until the rear of the train has passed out of the block. The train must run its length, in addition to the length of the block, before the signals will clear for the following train. Trains running at speed are spaced the length of the train, plus the length of the block, plus the distance between the distant and the home signals, for with the short blocks necessary for a maximum train movement the application of the brakes at the distant signal, as will be necessary if the signal, when passed, is indicating caution, will reduce the speed so materially that trains will be spaced a greater distance than if they were run far enough apart to get a clear indication at each distant signal.

The position of interlocking plants, stations and similar local conditions, the situation of which is fixed and cannot be changed to permit of the best placing of signals, will affect somewhat the time-spacing of trains. Where the interlocking and station signals occur at such intervals that the blocks

are of equal length, the regular spacing of trains can be maintained, but where the blocks are of unequal length trains will be kept further apart and the situation must be carefully studied. At those places where the blocks will be shorter than the required distances between the distant and the home signal the indication of the home signal must be repeated by two distant signals, and the furthest of the two is likely to be found a greater distance from the home signal than the necessary braking distance, thus giving an indication so far away that the train may be stopped some time before reaching the home signal.

Having the information at hand in regard to layout of tracks, grades, curvature, station locations, etc., it is necessary before the signals can be located on the plan that an assumption be made as to the maximum speeds which trains will be allowed to attain on the different parts of the line. The accompanying chart shows, in minutes and seconds, at the top of the diagram, the necessary time interval between trains at various speeds, with block signals fixed at different distances apart, as shown at the left of the diagram. The length of a train is assumed to be 520 ft., and provision is made for having at all times two home signals in the stop position behind a train. (This is to provide for an overlap, as is done on the New York City subway and the New York Central Electrified Lines.) Therefore, to give each train a clear distant signal, the time intervals between trains must be equal to the time required to run three times the length of one block, plus the length of the train, plus the distance run during the time (assumed to be 4 seconds) required for the home and the distant signals to move from the stop to the clear position, plus a sufficient time for an approaching engineman to see conveniently the distant signal, say 20 seconds. W. H. E.

Block Sheet. At a block-signal station, the sheet on which the movements of trains are recorded.

Block Station. A place from which manual block signals are operated. On important lines the block station is generally a "tower"—that is, a two-story building, with the signal levers and telegraph instruments in the second story.

Block System. "A series of consecutive blocks" (A. R. A.). The method of regulating the movement of railway trains, so as to maintain an interval of space between trains moving in the same direction (on the same track). It was first used on double-track lines, where a given track is used wholly by trains moving in one direction, but it is equally applicable to single-track lines used by trains moving in both directions. Given a line with stations, A, B, C, D, etc., a train is held (blocked) at A until the last preceding train has arrived at B, and at B until the preceding train has arrived at C, and so on. Thus the normal "space interval" between trains following one another is the distance between stations; but the minimum space is the thickness of the signal post, except as modified by the overlap (which see) in automatic block signaling and by rigid rules of procedure in manual block signaling. Signalmen are usually required to see that the rear end of a train has passed 300 ft. beyond the home signal (say at B) before giving permission to A to send on another train. This gives 300 ft. leeway as a provision against the danger of a train running past a stop signal and striking the rear of a preceding train which has been stopped immediately after entering a block section. The rules also require that if a train is unexpectedly stopped the rear trainman shall go back with hand signals to stop any following train. The block system was first used in England, about 1842. It was first used in America on the line between Kensington (Philadelphia), Pa., and Trenton, N. J., about 1863. In 1872, when the Pennsylvania took over this and other lines in New Jersey, the aggregate length of these lines worked by the space interval was 90 miles. The simplest form of the block system is the **Manual Block System,** which see. Other forms are the **Controlled Manual Block System, Electric Train Staff** and **Automatic Block Signal System.**

Bolt Lock (verb). To control a switch by means of a bolt lock.

(noun). A lock at a switch, consisting of a bolt controlled by the pipe or wire that operates the signal, which is used to permit trains to pass over that switch, so arranged that if the switch is not in proper position the signal connection cannot be moved to clear the signal. See Figs. 1710-1725.

Bond. See **Rail Bond.**

Bond Wire. See **Rail Bond.**

Bonding Plug. A piece of metal, somewhat like a rivet, used to fasten a wire to a rail. See **Channel Pin.** See Figs. 3594-3627.

Bonding Tube. A tapered iron or steel tube, coated with tin or copper, and having a longitudinal slit for fastening a bond wire to a rail. It is of the same general size and is used for the same purpose as a **Channel Pin,** which see. See Figs. 3594-3627.

Bootleg. On track-circuit connections, a short piece of wooden trunking, conduit, or conduit encased in concrete, enclosing the wire leading from the rail down to the horizontal part of the wire which leads to the battery box or the relay box. The term is also sometimes used to include the wire itself. See Figs. 3722-3772, 3851-3883.

Box Crank. Two or more cranks assembled in a common frame, each crank having an independent bearing. See Figs. 1154-1160.

Box Wheel. A group of chain wheels mounted in one frame. See Figs. 1371-1386.

Boxing. Wooden covering for pipe or wire lines. Used to exclude dirt or to prevent persons from stepping on the pipe or wire; also used to enclose pipe or wire lines when laid beneath streets.

Bracket Mast. The upright above the crosspiece of a bracket signal structure. See Figs. 3224-3273, 3282-3285.

Bracket Post. An arrangement for supporting two or more signals, side by side, on a single foundation. See Figs. 3224-3273, 3302-3305.

Break-down Switch. A panel switch employed in small three-wire systems, for connecting the positive and negative bus-bars so as to convert the system into a two-wire system, and thus, in case of a breakdown, to permit the system to be supplied with current from a single dynamo.

Breaking Down of Insulation. The failure of an insulating material, as evidenced by the disruptive passage of an electric discharge through it.

Bridge Circuit Controller. A device for connecting and disconnecting circuits at a drawbridge actuated by the same lever that moves the bridge lock or uncouples the pipe lines, or by a separate lever when the bridge is set in position (and locked), or when it is unlocked. See Figs. 2538-2549.

Bridge Coupler. The coupling at the end of a drawbridge in a pipe line, which extends from a cabin on the drawbridge to a function not on the drawbridge, or vice versa, designed to be quickly disengaged when the bridge is to be opened and quickly engaged, when the bridge is again closed. See Figs. 1739-1744.

Bridge Lock. A device for locking a drawbridge in its closed position, so interlocked with the signals approaching the bridge that they cannot be cleared unless the bridge is in proper position and locked. See Figs. 1742-1751.

Bridge Mast. The upright on a signal bridge. See 6, 7, Figs. 3224-3263, and Figs. 3274-3277.

Bridging Coils. In telephony, coils which are connected across a telephone circuit, as distinguished from coils placed in series in the circuit.

Bridle Rod. See **Front Rod.**

Brushes of Dynamo-electric Machines. Strips of metal, bundles of wire or wire gauze, slit plates of metal, or plates of carbon, that bear on the commutator cylinder of a dynamo, and carry off the current generated.

Buffer. See **Dash Pot.**

Bus Bar. On a switchboard or other terminal, a common conductor, usually a rectangular copper bar, from which taps may be made for connecting up recording instruments, such as ammeters, wattmeters, etc., or for taking off current for local circuits.

Butt End. A term applied to a jaw or bar whose end is cut off without tang or thread. See Figs. 1047-1133.

Butt Strap. An iron block, riveted to a tie plate, which see, to take the side thrust of the rail through a rail brace, which see.

Butting Collision. A collision between meeting trains —trains moving toward each other on the same track.

Buzzer, Electric. A call, not as loud as that of an electric bell, employing a humming sound by the use of a sufficiently rapid automatic contact-breaker. A telephone receiver for Morse circuits employing a vibrating contact key.

C

C. M. Abbreviation for Circular Mil.

C. R. Abbreviation for Cold Rolled. Used in connection with steel and iron.

Cab Signal. A signal in the cab of a locomotive. The term is used to include all arrangements for producing visual or audible indications on moving engines or cars by means of mechanical, electrical or magnetic devices situated on, at the side of or above the roadway, and producing effects on moving vehicles. Such devices have not come into general use and have been tried on but few railways. See **Automatic Stop.**

Cabin. A common name for a signal tower, which see.

Cable Box. A box provided for the reception and protection of a cable head.

Cable, Electric. An electrical conducting wire, or, more commonly, a collection of such wires, embedded in an insulating covering. Cables are used to conduct electric currents beneath rivers, as at drawbridges; for connections from poles to offices or cabins, or in any situation where a multiplicity of separate wires is objectionable, or where the conductors must be protected from gases, or other injurious substances, and in electric interlocking for connections from cabins to switches and signals, usually under ground. See Figs. 3919-3924.

Cable Head. A rectangular board provided with binding posts and fuse wires for the purpose of receiving the wires of overhead lines where they enter a cable.

Cable Tracer. One of the wires in a cable marked in such a manner as to be readily distinguishable from the other wires and used in tracing circuits through the cable.

Cage. A term sometimes applied to a **Switch Adjustment,** which see.

Cage Rod. A term sometimes applied to a **Throw Rod.** which see.

Calling-On Arm. A semaphore signal arm used to authorize a train to move (toward the signal cabin) past a home signal when the principal arm of the signal has to be left at "stop" because the block section is not clear or because for any reason it would not be allowable to permit the train to pass the signal unconditionally. The calling-on arm is usually smaller than the standard semaphore arm, and is placed below the standard size arm or arms. In England the calling-on arm is common, and it is rapidly finding favor in America. On the Pennsylvania the term has been applied to the dwarf-size arms, which are used on full-size posts (or on bridges) in the scheme for "speed signaling" which has been introduced in connection with three-position signals for interlocking, and which is illustrated in Figs. 265-276. In this scheme the small lower arm is inclined to the 45-deg. position to give the "calling-on" indication. Besides this indication that speed is to be controlled, the function of the arm is limited by the rules, which say that it is to be used only for low speed routes. Being thus limited, the calling-on arm can be used, for example, to move a train (or part of a train) past a home signal, forward, on the main line, to be coupled to the rear of a train which is stopped a short distance in advance.

Cantilever Bracket Post. A substitute for a bracket post. See Figs. 3224-3263, in which the cantilever signal 14 is a substitute for and conveys the same information as the bracket signal 21; likewise 18 may be substituted for 27. See **Bracket Post.**

Capacity Circuit. A circuit containing capacity but no inductance.

Capacity of Cable. The quantity of electricity required to raise a given length of cable to a given potential, divided by the potential. In a multiple cable, the amount of charge at unit potential which any single conductor will take up, the rest of the conductors being grounded. The ability of a conducting wire or cable to permit a certain quantity

of electricity to be passed into it before acquiring a certain potential.

Capacity of Line. The ability of a line to act as a condenser, and, therefore, like it, to possess capacity.

Capping. Covering for **Trunking,** which see.

Cathode. The conductor or plate of a decomposition cell connected with the negative terminal of a battery or other electric source. The terminal of an electric source into which the current flows from the electrolyte of a decomposition cell or voltmeter. The electrode of a bath, tube, body or device by which the current leaves the same. The negative electrode.

Caustic Soda Battery. A primary battery using caustic soda solution for the electrolyte.

Caution Card. In block signaling a written order issued by a signalman to authorize a train to enter a block which is not clear. See **Permissive Block Signaling.** Form B, of the Standard Code of the American Railway Association, is shown, reduced in size, below:

..................(NAME).................. COMPANY.

CAUTION CARD.

Block Station.............. ....M., ...190

To ENGINEMAN, train No............on...... .....track.

Block is not clear. You may proceed with caution expecting to find track obstructed.

....*Signalman.*

Enginemen receiving this card properly filled out and signed by the signalman, may proceed with the train under control prepared to stop short of any obstruction in the block.

[PRINT NAME.]
....*Superintendent.*

Another form (Form D) is used when the communicating wire from station to station is broken or otherwise unavailable.

Caution Signal. A signal indication denoting that a train may proceed under some restriction usually (in permissive block signaling) with the understanding that a preceding train moving in the same direction may be overtaken at **any point** in the block section, and that therefore the speed must be very low, except as the engineman is able to see a clear track for a considerable distance ahead. Thus, on a long, straight track, in clear weather, "cautionary" speed is not necessarily low speed. "Caution" is used, but with a different meaning, as the name of the indication of a distant signal which says "proceed," expecting to find the next home signal indicating **stop.** As the home signal referred to may be a mile or more away the distant signal does not require speed to be reduced or limited at any specific point, the reduction or limitation must be applied wherever it may be necessary in order to insure a stop at the home signal. If, when the home signal is seen, it proves to have been put in the clear position, the "caution" indication at once becomes void.

Cell. One unit of an electric battery.

Centimeter. The hundredth of a meter; or, 0.3937 inch.

Chain Wheel. A grooved wheel about 10 in. in diameter, mounted in vertical or horizontal bearings, about which ¼-in. chain is passed to change the direction of a signal wire line. For a short distance a chain is used in place of the wire and the chain is guided by the groove in the rim of the wheel. See Figs. 1338-1408.

Chain Wheel Stand. A casting carrying one or more chain wheels. A one-way chain wheel stand carries one wheel; a two-way stand carries two wheels.

Channel Pin. A device used to fasten a wire to a rail; a truncated cone, in which is cut a longitudinal slot of radius equal to that of the wire. The pin is inserted in a hole in the rail with the wire and driven home, thereby wedging the wire firmly in place. See Figs. 3603-3609, 3613, 3615.

Charging Current. The current employed in charging a storage battery or accumulator.

Check Lock Lever. In an interlocking machine, a separate lever which is used for **Check Locking,** which see. Also called traffic lever. See Figs. 2079, 2082.

Check Locking. A method of interlocking electrically the levers in two adjacent interlocking plants to permit train movements to be made against the current of traffic. In electric and electro-pneumatic interlocking plants there is usually provided in each tower a separate lever for each track over which reverse movements are to be made. These levers are connected with the mechanical locking in such a way that, when they are in their normal position, the signal for reverse movements is locked in the stop position and the signal for movements with the current of traffic is free to be moved. When both check lock levers are reversed the signal for normal movements is mechanically locked in the stop position and the dwarf signal (for reverse movements) at the adjacent interlocking is unlocked to allow reverse movements. See Figs. 2079-2082.

Choke Coil. A reactance used in connection with lightning arresters and placed in series with the line to be protected.

Chute. See **Battery Chute.**

Circuit Breaker. A switch, controlling an electric circuit, which normally is closed. See Figs. 2416-2549.

Circuit Closer. A switch, controlling an electric circuit, which normally is open. See Figs. 2416-2549.

Circuit Controller. A switch, push-button, plug, or any similar means for conveniently opening and closing an electric circuit. See Figs. 2416-2549.

Circuit, Electric. See **Electric Circuit.**

Circuit, Multiple. A compound circuit in which a number of separate sources or separate electro-receptive devices, or both, have all their positive poles connected to a single positive lead or conductor, and all their negative poles to a single negative lead or conductor.

Circuit, Open. A broken circuit. A circuit, the conducting continuity of which is broken.

Circuit, Parallel. A name sometimes applied to circuits connected in multiple. See **Circuit, Multiple.**

Circuit, Series. A compound circuit in which the separate sources, or the separate electro-receptive devices, or both, are so placed that the current produced in each, or passed through each, passes successively through the entire circuit from the first to the last.

Circuit, Short. A shunt or by-path of comparatively small resistance around the poles of an electric source, or around any portion of a circuit, by which so much of the current passes through the new path, as virtually to cut out the part of the circuit around which it is placed, and so prevent it from receiving an appreciable current.

Circuit, Shunt. A branch or additional circuit provided at any part of a circuit, through which the current branches or divides, part flowing through the original circuit, and part through the new branch.

Circular Mil. A unit of area employed in measuring the cross-sectional area of wires, equal to .7854 sq. mil. The area of a circle, 1 mil., or .001 in. in diameter. One circular mil. equals .000000785 sq. in. The area of cross-section of a wire in circular mils. is equal to the square of its diameter in mils.

Clear (verb). To put a signal in the position or aspect to indicate that a train may proceed.

Clear Signal. A common term to denote the indication of a signal in the "proceed" position. It may refer to a home signal indicating proceed at unlimited speed; or to such a signal indicating proceed at limited speed (over a diverging track); or to a distant signal indicating proceed, expecting to find the next signal clear. In Great Britain "all-clear" is used in the same sense.

Clearance Card. In block signaling a written order issued by a signalman to authorize a train to enter a block when the signal cannot be cleared. Form C of the Standard Code of the American Railway Association is shown, reduced in size, below:

————————(NAME)———————— COMPANY.

CLEARANCE CARD.

.................BLOCK STATION, ..., 190 , ...M.

To ENGINEMAN

Train No............on..................track. Signal cannot be cleared; proceed.

.... , *Signalman.*

This card must be used only in case of failure of block signal apparatus, and when block has been duly reported clear by the signalman at the block station in advance. The engineman receiving it duly dated, timed, and signed, may proceed.

[PRINT NAME.]
......................................*Superintendent.*

Clearance Point. At a convergence of two tracks that point beyond which the widest cars or engines, proceeding in the converging direction, cannot run without a possibility of fouling vehicles on the other track.

Clockwise Motion. A rotary motion whose direction is the same as that of the hands of a clock, viewed from the face.

Clockwork Signal. One of the early forms of automatic block signal mechanism; still in use to a limited extent in New England. It is a disk signal revolving on a vertical spindle. When the disk or target is visible to the engineman it indicates stop, and when turned with the edge toward an approaching train (disk not visible) it indicates clear. A common form has a second target of different shape mounted on the spindle at right angles to the stop target which serves for the clear indication. The stop target is usually painted red, and the proceed target, when used, is painted white or green. See **Night Signal Indication.** The spindle is rotated through a chain of gears similar to the works of a clock, by a weight suspended inside of the iron signal post. A detent operated by a magnet controlled by the track circuits prevents the disk from revolving more than one-quarter of a revolution for each operation of the signal.

Closed Circuit. An electric circuit which is complete. The term is familiarly used to denote a circuit which is normally complete. In railway signaling the normal condition of the apparatus is that which exists when no train is on the line. For example, in automatic block signaling of the simplest form the signal stands normally at "clear" or "proceed," in readiness for the next train. It is held in that position through the instrumentality of an electro-magnet, energized by a battery. To change the signal from this to the stop position, the current from the battery is cut off by opening the circuit at the track relay, thus de-energizing the signal magnet. With the apparatus arranged in this way the breaking of the circuit at any point, as by the unobserved corrosion of a wire or the failure of the current by the exhaustion of the battery, will result in setting the signal at stop, thus leading to the stopping of any train that may come along the line, and thereby calling attention to the fault. This is the only safe arrangement. If the circuit were arranged normally open (that is, normally broken at some point) so that it would require to be closed to set the signal in the stop position, any such failure of wire or battery would introduce a condition of danger, as the signal might stand at "clear" (because of the failure of the electric apparatus to move it to the stop position) when it ought to indicate "stop." See **Open Circuit.**

Closed-circuit Voltmeter. A voltmeter intended to be in permanent connection with the pressure it is designed to measure.

Closed Switch. A switch (in a railway track) which is set for the normal current of traffic; an outlying or siding switch, set for the main track.

Coil, Induction. An apparatus consisting of two parallel coils of insulated wire employed for the production of currents by mutual induction. A rapidly interrupted battery current, sent through a coil of wire called the primary coil, induces alternating currents in a coil of wire called the secondary coil. As heretofore made, the primary coil consists of a few turns of a thick wire, and the secondary coil of many turns, often thousands, of fine wire. Such coils are generally called Ruhmkorff coils, from the name of a celebrated manufacturer of them.

Colors of Signals. A semaphore arm gives its indication by form and position, independent of its color, but for convenience the blades are usually painted red for home signals and yellow or green for the distant signals. A white transverse stripe is common (see Figs. 225-228). On a few roads all signal arms are painted one color (yellow). The back sides of blades are painted white or a neutral color. In enclosed disk signals the disk is red for home (stop) signal, and for the distant it is green or yellow, according to the colors used in the light at night. The efficiency of an enclosed disk signal depends on the contrast between the appearance of the disk and that of the surrounding surface of the case. When the signal is cleared (the disk withdrawn from sight) the inner surface of the

back of the case (white) constitutes the clear signal. See **Night Signal Colors.**

Coleman Lock and Block Instrument. An improved form of the Sykes lock and block instrument for a controlled manual block system, devised by J. P. Coleman. See pages 27-45.

Common Wire. A wire used jointly or "in common" by two or more electric circuits, through part of the route of each. When two or more circuits are supplied with current from one source, as a battery, the main leads from the battery are "common" to all such circuits.

In early signal practice it was customary to economize in the use of wire by making the ground a "common" return conductor for nearly all circuits in the same manner as is still done in the telegraph. But on account of difficulty in maintaining good ground connections this practice has been discontinued to a large extent, the "common" return wire being substituted.

NOTE.—This practice, although at present in general use, has certain undesirable features. Its use results in complications in circuits, and occasionally trouble is caused by the common wire being overloaded, resulting in a drop in potential between different points. Again, if the common wire, as, for instance, at a power interlocking plant, becomes disconnected or broken it is likely to interfere with the operation of the entire plant, and also under certain conditions is liable to cause functions to operate improperly. Foreign currents also are sometimes collected or distributed by the common wire, especially where it extends several miles, as in automatic block signaling, and to limit the effects of such disturbing elements it is the practice on some roads to limit the length of common wires to a few miles.

Commutator. Any device for changing in one portion of a circuit the directions of electromotive forces or currents in another portion. A device for changing alternating into continuous currents, or vice versa.

Compensator. A device for increasing and decreasing the length of long lines of pipe or wire to adjust them to changes in the temperature of the atmosphere, so as to keep the length of the pipe or wire constant. In pipe lines this is accomplished, where the direction of the line is changed, by different arrangements of cranks, and in straight lines by a "Lazy Jack." For wire lines various automatic compensators have been tried and have been rejected as unsatisfactory. See **Pipe Compensator; Wire Compensator.** See Figs. 1162-1175, 1409-1410.

Condensance. Capacity reactance.

Condenser. A device for increasing the capacity of an insulated conductor by bringing it near another earth-connected conductor but separated therefrom by any medium that will permit electrostatic induction to take place through its mass. Any variety of electrostatic accumulator.

Conductance. A word sometimes used in place of conducting power. The reciprocal of resistance. In a continuous-current circuit the ratio of the current strength to the E.M.F. In an alternating-current circuit the quantity whose square added to the square of the susceptance is equal to the square of the admittance.

Conduction, Electric. The so-called flow or passage of electricity through a metallic or other similar substance. The ability of a substance to determine the direction in which electric energy shall be transmitted through the ether surrounding it. The ability of a substance to determine the direction in which a current of electricity shall pass from one point to another.

Conductivity. The capacity of a substance, as a wire, for conveying electric current; the reciprocal of electric **Resistance,** which see.

Conductor. Any substance which will permit the so-called passage of an electric current. A substance which possesses the ability of determining the direction in which electric energy shall pass through the ether in the dielectric surrounding it.

Conduit. A tube of wood, clay, iron or fiber, enclosing electric wires, usually under ground. See Figs. 3822-3850.

Constant-potential Circuit. A circuit whose potential is maintained approximately constant. A multiple-arc or parallel-connected circuit.

Contact Finger. See **Front Contact** and **Back Contact.**

Contact Rail. In automatic train-stopping or cab-signaling systems, a bar of metal, similar to or perhaps consisting of a piece of track rail, which is fixed on the ties, alongside of one of the rails of the track, or perhaps midway between the two rails, in such a way as to be rubbed by an electrical conductor fixed on the engine or the other vehicle. With suitable insulation and insulated connections the contact of the moving with the fixed part is made to complete an electric circuit as the train passes. Cab-signal systems have been proposed in which there would be a continuous contact rail throughout the length of the railway.

Continuous Current. An electric current which flows in one and the same direction. A steady or non-pulsating direct current.

Controlled Manual Block System. The manual block system safeguarded by the addition of electric locks, attached to the signal levers and controlled from the adjoining block stations, so arranged that a clear signal cannot be displayed to admit a train into a block without the simultaneous action and consent of the signalmen at both ends of the block. The controlled manual system was developed in England by W. R. Sykes, where it is known as "Lock and Block." In 1882 a few Sykes instruments were installed on the New York Central in and near New York City. Coleman's controlled manual instrument is an improved form of the Sykes instrument, devised by J. P. Coleman, and the few original Sykes instruments installed in the United States have been replaced by it. Track circuit control (at each station) is an important element of the system, but in some cases it is not used. By the addition of a complete track circuit throughout the length of the block sections the controlled manual system can be made to more surely provide against a collision due to the accidental breaking of a train. If, by accident or otherwise, the rear car of a train should be detached and left in a section, while the rest of the train passed out of it, and if in such a case the signalman at the outgoing end should carelessly assume that the whole of the train had passed him, it would be possible for him to empower the station at the

entering end to send forward a second train. The continuous track circuit prevents this, as in automatic block signaling. See **Electric Train Staff.** See pages 27-45.

Converter. A dynamo-electric machine having one armature and one field for converting alternating current to direct current, or direct current to alternating current. The term to be preceded by the words "alternating current-direct current" (A.C.-D.C.) or "direct current" (D.C.).

Convertible Lantern. A lantern equipped for the use of either oil or electric lamps.

Copper-clad Wire. An electrical conductor made with a steel center, surrounded by copper. For lines strung on poles, by the use of copper and steel in the right proportions, copper for conductivity and steel for mechanical strength, wire of a given conductivity can be made at a cost less than that for either copper wire or steel wire. The welding of the steel and the copper is done by the "Monnot" process.

Core, Lamination of. Structural subdivisions of the cores of magnets, armatures and pole-pieces of dynamo-electric machines, electric motors, or similar apparatus, in order to prevent heating and subsequent loss of energy from the production of local, eddy or Foucault currents.

These laminations are obtained by forming the cores of sheets, rods, plates, or wires of iron insulated from one another.

Coulomb. The practical unit of electric quantity. Such a quantity of electricity as would pass in one second through a circuit conveying one ampere.

Counter-electromotive Force. An opposed or reverse electromotive force which tends to set up a current in the opposite direction to that actually produced by a source. In an electric motor, an electromotive force produced by the rotation of the armature and opposed to that produced by the driving current.

Counterweight. In a semaphore, a weight so connected that, in case of breakage of the wire or the pipe controlling the signal, the weight will fall and pull the signal to the horizontal (stop) position. Any failure of a signal should result in an indication adverse to the movement of trains, thus tending to safety and to the discovery and repair of the defect which has caused the failure. Semaphores, in which the arm is inclined upward for the proceed indication, need no counterweight. See Figs. 1409-1410, 1639-1646, 1700.

Crane. See **Staff Crane.**

Crank. In interlocking work, a lever used to change the alinement or direction of travel of a pipe. Cranks are straight when the arms make an angle of 180 deg. with each other. See **Equalizer** and **Straight Arm Compensator.** "T" cranks have three arms and are shaped like the letter T. When the arms are at 90 deg. to each other the term "crank" is used alone. See Figs. 1134-1145, 1154-1160, 1177-1178.

Crank Stand. The frame in which cranks (in a pipe line) are supported. See **Crank.**

Cross (of wires). The accidental contact of electrical conducting wires. In signaling, such an accident, by increasing the current in a wire or reversing its polarity, or by energizing a wire which should be dead, may produce derangements of apparatus. Circuits controlling signals should always be so arranged that either a cross or a break will cause the signal to indicate stop, or if already thus indicating to remain so until the fault is corrected.

Cross Arm. An arm, usually of wood, fastened to a telegraph pole, near the top, at right angles to the pole; designed to carry the pins and insulators to which line wires are attached. See Figs. 3002-3043.

Cross Locking. In Saxby & Farmer interlocking, the transverse bar which is moved by the locking dog. See 26, Fig. 794.

Crossing Bar. A detector bar used near a crossing and operated by a separate lever in an interlocking machine. By its use a train on the crossing is protected against the wrongful clearing of signals for trains on conflicting routes. See **Fouling Bar.** See Figs. 750-753.

Crossover. A short track leading from one to the other of two parallel tracks. See Figs. 439-441, 756, 760-763, 770-771, 780-785, 1176, 1563-1567.

Crowfoot Zinc. A form of zinc plate used in a **Gravity Cell,** with a vertical stem and several radiating spokes or toes, resembling the foot of a bird. See Fig. 2320.

Current, Electric. See **Electric Current.**

Current of Traffic. On a double-track railway the normal movement of trains in a given direction, as for example, eastward on the south track, and westward on the north. To move westward on the south track or eastward on the north track, in that case, is "against the current of traffic."

Current Strength. In a direct current circuit the quotient of the total electromotive force divided by the total resistance. The time-rate-of-flow in a circuit expressed in amperes, or coulombs per second. In an alternating current the quotient of the total electromotive force divided by the impedance. See **Alternating Current.**

Cutout. In an electric circuit a switch for changing or stopping the flow of current, so that a piece of apparatus, as, for example, an electromagnet, which has formed a part of the circuit is left de-energized—cut out of the circuit. A safety fuse.

Cut Section. In automatic block signaling, a familiar term used in cases where a block section is too long to maintain a single track circuit (by reason of the tendency for leakage through ties and roadbed to reduce the difference in potential between the running rails). The block section is divided at the middle—or in extreme cases is divided into three parts—and is called a "cut section." A section which does not reach to the signal may repeat into the adjacent section by a relay, or it may be made to control the home signal directly by a line wire. See Figs. 406-483, 485, 487, 493-494, 498, 501, 505.

Cycle. In an alternating current a complete change in direction from any given value through zero to an equal value in the opposite direction and back. The frequency is expressed as the number of cycles per second.

D

D. C. Abbreviation for Direct Current.

Danger. A term formerly used to denote the "stop" indication of a signal; still used in the combined term "normal danger," meaning an automatic block signal system, in which the signals indicate stop

(or, in the case of a distant signal, caution) at all times except when a train is approaching.

d'Arsonval Galvanometer. The class of galvanometers in which the needle or mirror is attached to and actuated by a small coil which is suspended by means of a fine wire between the poles of a permanent magnet. The axis of the coil is normally at right angles with the lines of the field. Current is lead into the coil by means of the small suspension wire and leaves the coil by a flexible wire usually in the form of a helical spring attached underneath the coil.

Dash Pot. A cylinder with a piston, designed to act as an air cushion for a falling weight, the piston being attached to a rod supporting the weight. See 6, Figs. 523-526; 8, Fig. 537; 4, Fig. 580.

Dead-beat Galvanometer. An aperiodic galvanometer, or one whose needle comes quickly to rest instead of repeatedly swinging to-and-fro. A heavily damped galvanometer.

Deflecting Bar. A device for changing the direction of a line of pipe. See Figs. 1179-1204.

Deflecting Bar Leadout. See Figs. 1007-1009.

Deflecting Stand. See Figs. 1179-1204.

Derail (noun). Any device in a fixed location, for throwing cars and engines off the track. A short name for **Derailing Switch,** which see. See Figs. 740, 744, 750, 754, 756, 760, 762, 770, 784, 786, 787, 1621-1625; and Hayes Derails, Figs. 1626-1638, pages 196-197.

Derailing Switch. A switch designed to turn a train off the track for the purpose of preventing it from running into danger; used in connection with stop signals on lines approaching grade crossings of other railways, or drawbridges, or any particularly dangerous place. It may be interlocked with a stop signal so that when the derail is "open," to derail, the signal must indicate stop; and before the signal can be cleared the derailing switch must be set so as not to derail an approaching train. See Figs. 740-787. A diverging track, if not too sharply curved, serves the same purpose without causing derailment. Derailing switches worked by hand (sometimes not interlocked with the switch) are used near the ends of outlying side tracks, especially where a movement from the siding to the main line has the benefit of a descending grade. Such a derailing switch is regularly left open, so as to derail any cars which may by accident run from the siding toward the main line when no attendant is near.

Detector Bar. A device for preventing the movement of switches under trains. A long, thin strip of metal is mounted on pivoted links alongside of the track rail, on its outer side, in such a way that when moved longitudinally the bar is lifted higher than the top of the rail. The bar is so connected to the switch movement, with which it is used, that it must be lifted before the switch is moved. It is located either in advance or in rear of the switch, and sometimes both. If any pair of wheels is on the rail along which it is mounted the bar is prevented from moving by coming in contact with the wheel tread which projects over the edge of the rail. If the detector bar cannot move, the switch cannot be moved, and the arrangement therefore prevents throwing a switch under a car. Detector bars are used with both mechanical and power-operated switches. They derive the name "detector bar" from the fact that the signalman in a mechanical interlocking can detect by the pull on the lever, whether the detector bar is blocked. In power interlocking they are now being replaced in many installations with electric track circuits controlling electric locks on the switch levers. See **Detector Bar, Inside;** also **Electric Detection; Detector Track Circuit, Detector Locking.** See Figs. 1479-1485, 1543-1617.

Detector Bar (inside). An arrangement for preventing the movement of a switch while it is occupied by a car. The common **Detector Bar,** which see, keeps the switch locked by the pressure of the outer part of the treads of the wheels of the car. The inside bar is controlled by the flanges of the wheels. The older form of inside bar was arranged normally to lie flat, and in moving was turned upward by the movement of a long rod lying parallel to the bar and fixed to it, the rod being turned on its axis. A later form is worked in about the same way as the outside bar. The effectiveness of the outside bar depends on having car wheels with treads wide enough always to extend a good distance outside of the head of the rail. With wide-headed rails this is an uncertain factor.

Inside detector bars are objectionable because, by reason of the presence of switch rods and other track accessories, it is impossible in many situations to put the bars where they are needed, and also because wheel flanges are not of uniform depth. For this and other reasons the outside bar is more generally used. But the introduction of rails with very wide heads has lessened the effectiveness of outside bars; because with the width of the wheel treads only a little greater than the width of the rail head the bar may not be properly held down. This has led to the introduction of "electric detection" for this purpose, and also "switch guards," designed to approach the wheel from the side instead of from below, as in Figs. 1604-1607, and 1608-1611.

Detector Bar Driving Piece. A stud and plate, or eye, bolted to a detector bar, on which is attached the driving rod connected with the switch movement with which the detector bar is used. See Figs. 1557-1559.

Detector Bar Link. A short link supporting a detector bar, and so pivoted on a clip fastened to the rail that the detector bar in moving longitudinally must also move upward and above the top of the rail. See Figs. 1543-1544, 1568-1603.

Detector Bar Stop. A lug bolted to the rail on which the detector bar rests when the stroke is completed. See Figs. 1545-1561.

Detector Locking. See **Electric Detection.**

Detector Track Circuit. A track circuit used in connection with electric detection, which see. So called because used to perform the same function as a detector bar.

Diagram, Track. See **Track Indicator, Track Model.**

Diaphragm Valve. A valve, controlling the admission of compressed air from an operating pipe to a switch or signal cylinder, which is itself worked by compressed air in another pipe—the control pipe. The pressure in the control pipe, increased or diminished by the signalman in the cabin, moves a flexible leather diaphragm up or down and thereby

actuates the valve stem. See **Pneumatic Interlocking**, Figs. 2029, 2031, 2033.

Dielectric. Any substance which permits electrostatic induction to take place through its mass.

The substance which separates the opposite coatings of a condenser is called the dielectric. All dielectrics are non-conductors.

All non-conductors or insulators are dielectrics, but their dielectric power is not exactly proportional to their non-conducting power.

Substances differ greatly in the degree or extent to which they permit induction to take place through or across them. Thus, a certain amount of inductive action takes place between the insulated metal plates of a condenser across the layer or air between them.

A dielectric may be regarded as pervious to rapidly reversed periodic currents, but opaque to continuous currents. There is, however, some conduction of continuous currents.

Differential Relay. A relay, the coils of which have two or more different windings; or a relay having two or more magnets acting in certain relation to each other. See Figs. 500, 502, 504, 505.

Direct Current. A current of electricity constant in direction as distinguished from an **Alternating Current,** which see. A continuous current. The current derived from all primary and storage batteries is direct current.

Direct Current Converter. Converts from a direct current to a direct current of different voltage.

Disengaging Lever. A lever hung by shackles from the balance lever of a signal when the signal is wire connected. The pulling and back wires, which see, are hooked to the disengaging lever in such a manner that should the back wire break the disengaging lever would be released and fall to the ground, thereby disconnecting the signal from its operating mechanism and allowing it to go to the stop position. See Figs. 1409-1410.

Disk Signal. A signal in which the day indications are given by the color or position of a circular disk. The term is commonly restricted to an **Enclosed Disk Signal,** which see. A **Clockwork Signal,** which see, is a disk signal in which the day indications are given by the position of the disk as it is turned to one or another of two positions by the revolution on its axis of a vertical spindle. See Figs. 512-520.

Distant Signal. A fixed signal situated 1,500 ft. to 3,000 ft. or more in the rear of a home signal to indicate to an engineman whether or not he may expect to find the home signal in the clear position. It is distinguished from home signals by a notch in the end of the blade. Finding the distant signal in the "clear" position, trains may proceed at unchecked speed, while if it shows "caution" it is a warning that the train must be prepared to stop at the home signal. On a line where, by reason of curves and intervening buildings, hills or trees, the home signal cannot be seen by the approaching engineman until he is quite near it; or on any line, curved or straight, when the engineman's view is obscured by fog or by falling snow, distant signals are necessary in order to avoid delay to fast trains, as without this preliminary information the speed of such trains would have to be materially slackened in order to enable the engineman to be sure of the reading of the home signal before he passed it. A mechanical distant signal is so interlocked that it can never be cleared until the home signal is cleared, and if there are other signals for that route at that station on that track the distant is so interlocked that all of them must be cleared before it can be cleared. A distant signal may be fixed on the same post with the home signal for the next section in the rear, and in that case it is arranged to be controlled by the latter in such a way that whenever the home goes to stop the distant will go to caution, even if its own home signal (a block in advance) does not require it to do so. This is done to avoid giving to enginemen what might seem to be two inconsistent indications at the same point. In the automatic block signal system the distant signal is controlled by the home signal, and is usually mounted on the same post with the first home signal in the rear. In a system of **Three-Position Automatic Block Signals,** which see, each signal gives a distant indication for the next signal in advance. The various forms and indications of distant signals are shown in Figs. 226, 231-235, 252, 253, 257-259, 264, 310-318. See **Home Signal.**

Distant Switch Signal. A signal, arranged like a mechanical distant signal, but used only to indicate the position of an outlying switch. Its lever is usually interlocked with the lever of the switch. Distant switch signals (for trains running in the "facing" direction) were used considerably before block signals were common; but when the block system and interlocking are introduced the switch signal usually is either removed or is made a part of the new system. See Figs. 1692-1695.

Dog Chart. A diagrammatic representation of the mechanical locking for an interlocking machine; used as a working plan in making up and fitting the locking. See Figs. 741-1006.

Dog Locking. See **Locking.**

Doll. A word, of doubtful origin, sometimes used to designate a short signal post, as the bracket masts of a bracket signal.

Double Jaw. See 46-53, Figs. 1047-1121.

Double-Pole Switch. A switch which simultaneously breaks the circuit of both positive and negative leads.

Dummy. Literally, a counterfeit; used to designate a bracket mast on a bracket signal, bearing no signal arm and designed merely to aid, by its position relative to the other bracket masts in showing to which of two or more tracks a signal applies. A dummy may carry a light of distinctive color to fulfil its function at night.

Duplex Lock. A lock for a switch with two plungers, one of which locks the switch in its normal position and the other in the reversed position. It is so arranged that both cannot enter the same hole in the lock rod. See F, Figs. 1467-1478.

Dwarf Interlocking Machine. A small interlocking machine often set out of doors. In a common form of two-lever machine one lever works the switch and the other a distant switch signal. See Fig. 1004. Except in this case these machines are used only on low-speed tracks, as in freight yards, and the locking is lever-locking (not "preliminary"). See Figs. 1703-1705, 3405-3510.

Dwarf Semaphore Signal. Commonly abbreviated to "dwarf." A low semaphore signal used for giving indications for low-speed movements, as through an interlocking plant in the reverse direction to the

normal current of traffic or on or from a side track. Dwarf semaphore signals are used also to give indications in the normal direction, as in the case of movements from a main track to a side track in the normal direction, the dwarf being set close to the high signal post. Dwarfs are frequently used at terminals for movements in the normal direction. See Figs. 1668-1686. The arm of a dwarf is about three inches wide and nine inches long, and is usually about 2 feet above the level of the rail. It is often made of rubber or thin sheet metal to prevent damage in case of fouling with cars or locomotives. The day indications of dwarf arms are the same as for full-size semaphore arms, as shown in Figs. 225-276. For the night indications by color, see **Night Signal Indications.** Figs. 277-307, show usual arrangements of dwarf and high signals with the routes which they control.

Dynamo. An electro-mechanical machine for transforming mechanical energy to electric energy and vice versa. When used to furnish electric energy it is called a generator and when used to furnish mechanical energy, a motor.

Dynamometer. A general name given to a variety of apparatus for measuring power.

E

E. M. F. Abbreviation for Electromotive Force.

Eddy Currents. Induced currents produced in the armature core of a dynamo or any small closed circuit in the presence of a changing magnetic field. See **Induced Currents.** See Figs. 680-684.

Effective Current Strength. The strength of an alternating or sinusoidal electric current, determined by its heating effect; or, in other words, the thermally effective current strength. That value of the current strength of a sinusoidal or alternating current which is equal to the square root of the mean square of the instantaneous values of the current during one or more cycles. The square root of the time average of the square of the current.

Effective Reactance. In an alternating current circuit, the ratio of the wattless component of an electromotive force to the total current. Apparent reactance.

Effective Resistance. In an alternating current circuit, the ratio between the energy component of an electromotive force and the total current.

Effective Value. That instantaneous value of alternating current which is equal to a direct current having the same heating power as the given alternating current. This value is $\frac{1}{\sqrt{2}}$ or .707 times the maximum value.

Efficiency. The efficiency of an apparatus is the ratio of its output to its input. The output and input may be in terms of watt-hours, watts, volt-amperes, amperes, or any other quantity of interest, thus respectively defining energy efficiency, power efficiency, apparent power efficiency, current efficiency, etc. Unless otherwise specified, however, the term efficiency is ordinarily assumed to refer to power efficiency.

When the input and output are expressed in terms of the same unit, the efficiency is a numerical ratio, otherwise it is a physical dimensional quantity.

Electric Bell. See **Bell, Electric.**

Electric Circuit. A simple electric circuit consists of a source of electrical energy, a conductor to carry the current to some form of electrical device or machine to utilize the current and another conductor to complete the circuit to the source of energy. In D. C. circuits the source may be a battery, either primary or storage, a dynamo-machine or a converter. In A. C. work the source may be an alternator or transformer. The conductors for either current may be any of the metals or other substances having the property of conductivity. The most common conductors in commercial use are copper or iron wire. The earth is a conductor, or more properly a reservoir of electricity, and by providing good ground connections may be made to form a portion of a closed circuit. This is not always feasible in signal work, however, on account of the difficulty in maintaining good ground connections and also on account of the interference caused by other circuits which depend on ground return. In signaling the devices to be operated are very numerous. They include relays, signal, switch, and derail operating mechanisms, indicators, annunciators, locks, signal lights, electric bells, and staff and controlled manual signal apparatus.

Circuits may be normally open or normally closed, and a number of devices may be used either to open a closed circuit or to close an open circuit. Some such device is ordinarily included in every circuit. In D. C. circuits the calculation of the value of the current flowing can be made by the application of **Ohm's Law,** which see, or the value can be measured by means of instruments included in the circuit. In A. C. circuits it is necessary to calculate the inductance and capacity of the circuit, then the inductive and capacity reactances and obtain the relation of current to voltage by the use of both these reactances and the resistance.

For divided circuits the current flowing in each branch is inversely proportional to its resistance.

Electric Current. The quantity of electricity per second which passes through any conductor or circuit, when the flow is uniform. The rate at which a quantity of electricity flows or passes through a circuit. The ratio, expressed in terms of electric quantity per second, existing between the electromotive force causing a current and the resistance which opposes it.

The unit of current, or the ampere, is equal to one coulomb per second. (See **Ampere,** and **Coulomb.**)

The word current must not be confounded with the mere act of flowing; electric current signifies rate of flow, and always supposes an electromotive force to produce the current, and a resistance to oppose it.

The electric current is assumed to flow out from the positive terminal of a source, through the circuit and back into the source at the negative terminal. It is assumed to flow into the positive terminal of an electro-receptive device such as a lamp, motor, or storage battery, and out of its negative terminal; or, in other words, the positive pole of the source is always connected to the positive terminal of the electro-receptive device.

The current that flows or passes in any circuit is, in the case of a constant current, equal to the

electromotive force, or difference of potential, divided by the resistance, as:

$C = \frac{E}{R}$ (See Ohm's Law.) The flow of an electric current may vary in any manner whatsoever. A current which continues flowing in the same direction no matter how its strength may vary, is called a continuous current, or sometimes a direct current. If the strength of such a current is constant, it is called an unvarying current; if its strength is not constant, it is a varying continuous current. A regular varying continuous current is called a pulsatory current. A current which alternately flows in opposite directions, no matter how its strength may vary, is called an alternating current. This may be periodic or non-periodic.

Electric Detection. The use of track circuits and relays for controlling electric locks on the switch or signal levers of an interlocking machine, or opening the controlling circuits of switches to prevent switches from being thrown under cars, a function originally performed by a **Detector Bar,** which see. Electric detection, however, is usually extended to the fouling points of the switch controlled, and may be used instead of or in addition to detector bars. See Figs. 2055-2088.

Electric Interlocking. Interlocking apparatus, in which the switches and signals are worked by electric motors or electromagnets. See Figs. 1762-1954.

Electric Lock. See **Lock, Electric.**

Electric Locking. See **Locking, Electric.**

Electric Motor. See **Motor, Electric.**

Electric Railway. A railway operated by electric power. Street railways extending many miles, from town to town, are called interurban. These and all electric lines operated by power drawn from a power house through an overhead wire by a wheel contact are called trolley roads. On many electric lines in the streets of large cities power is taken from a conductor laid in a conduit beneath the surface of the street. On many elevated and underground city railways and on electrified lines of some steam roads power is taken from a third rail. On a few interurban lines and on certain steam lines high-tension power is taken from overhead conduits by sliding contacts. On the majority of interurban roads the signaling is incomplete or entirely lacking, the moderate speeds and the absence of large terminals and junctions being held to warrant dependance on less costly methods. As speeds are increased standard signals and signaling methods are found necessary.

Electric Selector. An electromechanical device by which the electric circuit of any one of a number of audible or visible signals or other devices may be controlled from a distant point without affecting any of the other apparatus or devices. One form of selector is used for selective calling in telephone or telegraph train dispatching or message service; also for the control of signals from a distant point. See **Selective Signaling,** pages 126-132, Figs. 714-739. Another form of selector, commonly called a switch box, is controlled by the points of a switch and used to determine which arm of a signal or which signal of a group shall be cleared when the switch is moved to a given position. See Figs. 2416-2486.

Electric Slot. A device in which the connection between a signal arm and its operating mechanism is controlled by an electromagnet, the connection being broken when the magnet is de-energized and established when the parts are in proper mechanical relation and the magnet energized. Commonly used in semi-automatic block signaling to prevent the clearing of a signal, or to cause it to assume the stop position when the route or track section, the use of which by trains is governed by the signal, is obstructed. In telephone train dispatching it is used to prevent the clearing of the signal without the consent and co-operation of the dispatcher. See Figs. 3479-3492.

Electric Switch Lock. An electric lock controlled from a signal cabin and attached to the operating connection of an outlying switch to prevent the switch from being moved without the knowledge and consent of the signalman in the cabin. A telephone or a key and bell are usually added in the mechanism case to provide a means of communication between the switch and the cabin. With a telephone attachment a condenser is sometimes employed and the bell circuit or switch lock control circuit is used for the telephone circuit. See Figs. 2813-2830.

Electric Train Staff System. A method of regulating the movements of trains used commonly on single track lines. In the absolute staff system only one train at a time is allowed in a section between block stations. This is accomplished by requiring an engineman to have as his authority for entering a section a staff or small metal rod, the staffs being kept in machines at the stations so electrically locked between adjacent stations that only one staff from the two machines can be removed at one time. In the permissive staff system additional trains may be allowed to follow the first one into the section, the engineman of such following trains having for his authority to proceed a section of a divisible staff known as a permissive staff. This staff must be reassembled and locked in the instrument at the outgoing end of the section before a staff can be removed from that instrument to allow a train to proceed in the opposite direction. The pusher attachment for the train staff system provides a staff for the engineman on the pusher engine at the same time the staff for the engineman on the through engine is released. The circuits are arranged to lock both machines until the pusher staff has been returned to the instrument from which it was taken, and the through engine staff locked in the instrument at the other end of the section. The staff may also be designed to serve as a key for switches within the section. See pages 27-45; Figs. 346-405.

Electrical Bridge Coupler. See **Bridge Circuit Closer.**

Electrode. Either of the terminals of an electric source. Either of the terminals of an electric source that are placed in a solution in which electrolysis is taking place. Either of the electro-therapeutic terminals of an electric source.

Electrogas Signal. A semaphore signal worked by compressed carbonic acid gas. See Figs. 583-590.

Electrolysis. Chemical decomposition effected by means of an electric current—Houston. The opposite of the electrochemical action which takes place when current is generated in a voltaic cell. The action of the plates and electrolyte in charging a storage battery is electrolysis. The stable chemical elements and compounds of pure lead, lead oxide and sulphuric acid are dissociated by the pas-

sage of the charging current through the battery and combine to form unstable chemical compounds which do not become active, however, until the external circuit is closed. When the battery is discharging, exactly the opposite chemical reactions take place, the unstable compounds rearranging themselves to form the original stable compounds and this chemical change is accompanied by the generation of an electric current. Electrolysis manifests itself in the form of corrosion of pipes, wires, etc., buried under ground or exposed in damp places to the effects of stray electric currents. The moisture in the air combined with carbonic acid or in damp ground with earthy salts forms the electrolyte, which is necessary for the electrolytic action to take place. The pitting or corrosion of pipes appears at the point where current leaves the metal through the earth. It may occur even with currents of very low voltage.

Electrolyte. The liquid surrounding the plates or elements of an electric cell, containing in solution the chemicals which act on the elements to produce an electrochemical current. The electrolyte is the conductor of the current within the cell between the plates. It is usually a dilute acid or a solution of acid derivative salts in water, or a strong alkaline solution.

Electrolytic Decomposition. The separation of a molecule into its constituent ions or radicals by the action of an electric current.

Electromagnet. The magnet produced by the passage of an electric current through a circuit of insulated wire. In common practice, electromagnets consist of a coil or coils of insulated wire, wound about a soft iron core. See **Magnet.**

Electromagnetic Induction. A variety of electrodynamic induction in which electric currents are produced by the motion either of electromagnets, or electromagnetic solenoids.

Electromechanical Slot. See **Electric Slot.**

Electromotive Force. The force which starts or tends to start electricity in motion. The maximum or total generated difference of potential which exists in a circuit.

Electromotive Force of Induction. The electromotive force developed by any inductive action.

Electronegative. In such a state as regards electricity as to be repelled by bodies negatively electrified, and attracted by those positively electrified. The ions or radicals which appear at the anode or positive electrode of a decomposition cell.

Electro-pneumatic Interlocking. Interlocking apparatus in which the switches and signals are worked by compressed air, but the valves which control them are operated electrically from the tower. See Figs. 1955-2028.

Electro-pneumatic Signals. Semaphore signals worked by compressed air and controlled by electric apparatus. In electro-pneumatic interlocking the electric control is managed by the signalman in the tower; in electro-pneumatic block signaling the air-valves at the signals are controlled by the track circuit. See Figs. 591-602, 685-692.

Electropositive. In such a state, as regards an electric charge, as to be attracted by a body negatively electrified, and repelled by a body positively electrified. The ions or radicals which appear at the cathode or negative electrode of a decomposition cell.

Elevator. In a battery chute, the movable frame supporting the jar or jars, and its rope, arranged for conveniently raising the battery for inspection. See Figs. 2364, 2366, 2370-2387, 2396.

Enclosed Disk Signal. The simplest and earliest form of automatic block signal, introduced in 1871, and still in use to a small extent. The signal indications are given by color, both day and night. A circular disk of light cloth or thin metal, colored red or green, enclosed in a weatherproof case, with a glass front, is displayed for the day indication of stop or caution and withdrawn from sight for the proceed indication. See Figs. 512-520, 3419-3420, 3432-3433.

End Post. See **Insulated Rail Joint.**

Equalizer. See **Straight Arm Compensator.** See Figs. 1174-1175, 1177-1178.

Escapement Crank. A crank, used in a "switch and lock movement," by means of which a single stroke of a lever performs three operations: First moves the detector bar and unlocks the switch; second moves the switch, third moves the detector bar back and locks the switch. See Figs. 1445-1450.

F

F. P. Abbreviation for Facing Point.

F. P. L. Abbreviation for Facing Point Lock.

Facing Point Lock. A lock for an interlocked switch, worked or controlled by the signalman, so called because used chiefly at facing point switches and seldom or never at trailing point switches. In and near large terminals all switches are provided with locks, all being frequently traversed by trains in both directions. The operating connection of a switch ordinarily holds it in position; the lock is an additional provision for insuring accuracy of movement. At a trailing point switch extreme accuracy is not essential. See Figs. 1479-1484.

Facing Point Switch. A switch so situated, as related to an approaching train, that the pointed ends of the switch rails point toward the train. To a train coming from the opposite direction the same switch would be "trailing." In British practice the word "points" (the two pointed switch rails) has the same meaning as the American term "switch," and the English say simply "facing point." At a facing point switch a train takes either one or the other of two routes. At a trailing point, if the switch is not in the right position, the wheel flanges will crowd the movable rails to one side, and if the operating connections are rigid they will be broken. At non-interlocked switches such connections are usually fitted with a stout spring, not disturbed by ordinary strains or shocks, which will yield if the rails are thus forced out of position, and return them to their former position as soon as the wheels have passed. See Figs. 1479-1484.

Feeder. An electric circuit, used to supply power to a station or service, as distinguished from circuits confined to a single station or used for other purposes than supplying power.

Field. A term sometimes used for a magnetic field.

Field, Magnetic. The region of magnetic influence surrounding the poles of a magnet. A space or region traversed by lines of magnetic force. A place where a magnetic needle, if free to move, will take up a definite position, under the influence of the lines of magnetic force.

Fish Wire. A wire used to draw another through a tube or other opening.

Fixed Signal. A signal of fixed location indicating a condition affecting the movement of a train, as distinguished from signals given by motion of the hand or by a flag or a lamp. Flags or hand lanterns may be temporarily set in fixed locations. All block and interlocking signals are fixed signals.

Floor Push. An electric circuit closer fixed in the floor where the signalman can conveniently close the circuit by pressing downward on a button with his foot. See Figs. 2498-2503, 2505-2507.

Flux, Magnetic. The number of lines of magnetic force that pass or flow through a magnetic circuit. The total number of lines of magnetic force in any magnetic field.

Fouling Bar. A detector bar, which see, placed at or near a fouling point to prevent the movement of certain functions while a train is on the bar. See **Crossing Bar.**

Fouling Point. In the case of converging tracks, that point where a car running toward the junction would come in contact with a car or train standing or moving on the other track.

Foundation. The foundations for mechanical signal connections—pipes and wires—which are set at suitable intervals along the line, consist usually of heavy planks, or of concrete, or of cast iron.

Frequency. The number of cycles or alternations per second in an alternating current. The frequencies most used in commercial work are 25 and 60 cycles per second.

Frequency Changer. A piece of apparatus for changing from one frequency to another, consisting of a motor driving either an ordinary alternating current generator or a machine.

Frequency Converter. A machine for converting from an alternating current system of one frequency to an alternating current system of another frequency.

Frequency of Alternation. The number of cycles or periods executed by an alternating current in unit time. The periodicity. The two standard frequencies are now 25 and 60.

Frequency Relay. An alternating current relay so made that it will act effectively only when energized by an alternating current of a certain frequency.

Front Contact (of a relay). An electrical contact which is made when the armature of the relay is attracted to the pole piece of the magnet coils by current flowing through the coils. See **Relay** and **Back Contact.**

Front Locking. The mechanical locking in a "Standard" interlocking machine which acts in a plane outside of the tappets. See Figs. 853-902.

Front Rod. See **Switch.** See Figs. 1532-1542.

Frost Board. In a battery chute or well a cover beneath the main cover more effectually to protect the battery from freezing. See Figs. 2370, 2371, 2372, 2374, 2375-2382, 2383-2387, 2396, 2397, 2399, 2400, 2405-2406.

Function. See **Operated Unit.**

Fuse. In electrical work a strip, plate or bar of some readily fusible alloy, designed to melt, and thus break the circuit in which it is placed, if a current passes which is of sufficient power to melt it. The fuse is so designed as to melt before the current is powerful enough to endanger apparatus in other parts of the circuit. The melting of the fuse is due to the heat generated by the passage of the current. Fuses are sometimes enclosed in glass tubes, or are placed between mica strips to prevent injury to surrounding apparatus. A cartridge fuse consists of a piece of metal as above, surrounded by some chemical compound, the purpose of which is to extinguish any arc that might form when the fuse "blows."

Fusee. A chemical fire light, like a roman candle, giving a bright light—red or green or yellow—as a stop or slow signal. The fusee is thrown off the rear of a train as a warning to any following train. Its stick has a sharp point, and it can be thrown so as to stand upright. It is made to burn a definite length of time, either five or ten minutes. At the end of that time it is reduced to ashes. It is the only practicable stop signal in use which can be effectively given at will from a moving train. See **Time Interval System.**

G

Gain Stroke. A device for securing extra stroke in a line of connections used at the end of a long wire line where elasticity and lost motion have reduced the throw. It usually consists of a crank having arms of different length; an escapement crank, a special jaw or a system of pulleys. See 41, 42, 43, Figs. 1047-1121; Figs. 1172-1173, 1348-1349.

Galvanometer. An apparatus for measuring the strength of an electric current by the deflection of a magnetic needle. A current measurer.

The galvanometer depends for its operation on the fact that a conductor, through which an electric current is flowing, will deflect a magnetic needle placed near it. This deflection is due to the magnetic field caused by the current.

The needle is deflected by the current from a position of rest, either in the earth's magnetic field or in a field obtained from a permanent or an electromagnet. In the first case, when in use to measure a current, the plane of the galvanometer coils must coincide with the planes of the magnetic meridian. In the other case, the instrument may be used in any position in which the needle is free to move.

Galvanometers assume a variety of forms according either to the purposes for which they are employed, or to the manner in which their deflections are valued.

Gassing. The evolution of gas from the plates of a secondary or storage battery.

Generator, Electric. See Dynamos. See Figs. 2860-2889.

Gravity Cell. A common form of primary cell using zinc and copper as the elements and a solution of zinc sulphate and copper sulphate for the electrolyte. The zinc in the form of an open wheel or crowfoot is suspended in the top of the jar and the copper in the form of a cylinder or star rests on the bottom and is surrounded with crystals of blue vitriol (copper sulphate). The solution of copper sulphate, being heavier than the solution of zinc sulphate, sinks to the bottom, hence the name, gravity cell. The reaction which takes place on a closed circuit is very simple. The copper sulphate is decomposed, depositing metallic copper on the copper plate, and the sulphuric acid thus liberated attacks the zinc plate, yielding zinc sulphate. There is a distinct line of demarcation between the two liquids of the electrolyte, and the best test of the condition of the battery is by observing when the zinc sulphate solution increases, extending down

near the copper, denoting an excess of zinc and a deficient amount of copper sulphate. The zinc solution should then be drawn off and more copper sulphate solution added. This is done through a tube, so as not to disturb the equilibrium of the liquids. The zinc must be renewed occasionally and the copper taken out and cleaned. A copper plate made unwieldy by accretions of copper must be replaced. The ordinary gravity cell has a voltage of about 0.9 volt, and will remain active for long periods without appreciable polarization on a closed circuit. For this reason it is almost universally used for supplying current to track circuits in signal work and for telegraph circuits where small amounts of current at low voltage are required. See Figs. 2297-2324.

Grid. See **Resistance.** See also Figs. 678-679.

Ground. Connection of an electric conductor to earth, usually by attaching it to a metal plate or cone, buried in the ground. The term is commonly used in referring to an accidental connection of a circuit with the ground or any large object in which the current is dissipated. See Figs. 2765-2767, 2787, 2788.

Ground Lever. A switch or signal lever arranged to be handled by a person on the ground, as at an outlying switch or a derail, in distinction from a lever of an interlocking machine in a tower. See Figs. 3495-3510.

Ground Signal Post. An ordinary signal post, as distinguished from one on a bridge, bracket post or other structures above the ground.

H

Harmonic Currents. Periodically alternating currents varying harmonically. Currents which are harmonic functions of time. Sinusoidal currents.

Head Block. The long tie or sleeper on which the points of a switch rest.

Head Rod. The rod next to the front rod of a switch, which see.

High Signal. A general term applied to all full-sized semaphore signals mounted on a post, bridge, building or other structure above the level of the top of a car or locomotive. When two or more high arms are fixed on the same post, the lowest one is usually placed at a minimum height of twenty feet above the level of the rails and a minimum vertical distance of six feet is preserved between the signals on the same post. All signals for trains running at full speed are high. Low signals (dwarf) are used only for slow movements. See **Dwarf Signal, Pot Signal, Semaphore Signal.**

Highway Crossing Signal. Usually some form of electric bell, which see, mounted on a post near a highway crossing. Used to announce the approach of trains. See Figs. 2089-2242.

Home Signal. A fixed signal at the point at which trains are required to stop when the route is not clear. As a block signal it stands at the entrance to the block. At interlocking plants home signals stand immediately in the rear of the switches, derails, crossings and drawbridges which they protect. A home signal of an interlocking plant, when cleared, denotes that the route governed by the signal has been made ready for a train movement over it. The term home signal was originally applied on British railways to the signal mounted on or near the signal box, controlling the entrance of trains into a block section.

A home block signal in a manual or controlled manual system, when in the stop position, must not be passed except on receipt of the proper authority, either written or by flag, obtained from the signalman. An automatic home block signal, when in the stop position, indicates "Stop, wait (a specified length of time) and proceed cautiously, expecting to encounter obstruction." See **Permissive Block Signaling.** Home block signals, when in the clear position, indicate "Proceed; block is clear."

Semaphore home signal arms are usually made with square ends to distinguish them from **Distant Signals** (which see), the arms of which are made with forked or "fish-tail" ends. On many roads a further distinction is made by using arms with pointed ends for automatic home block signals and square end arms for all other home signals.

In **Three-Position Automatic Block Signaling,** which see, the functions of the home signal and the distant signal are combined in a single arm. See Figs. 225-307. See **Distant Signal, Advance Signal, Dwarf Signal, Night Signal Indications, Starting Signal.**

Home Track Circuit. That track circuit which governs the indication of the home signal. It prevents the home signal being cleared while any part of train is between home and advance block signals. It is located between home and advance block signals.

Horizontal Chain Wheel. A chain wheel whose axis is vertical. Used to change the direction of a wire line. See Figs. 1338-1367, 1371-1390.

Horizontal Locking. Mechanical locking arranged in a horizontal plane. See **Saxby & Farmer, Stevens** and **Dwarf Interlocking Machines.** See Figs. 790-850, 1004-1006.

Horsepower. A commercial unit of power, activity, or rate-of-doing-work. A rate-of-doing-work equal to 33,000 foot pounds per minute.

Horsepower, Electric. Such a rate-of-doing electrical work as is equal to 746 watts, or 746 volt-coulombs per second.

Hysteresis. A lagging behind of magnetization relative to magnetizing force. Apparent molecular friction due to magnetic change of stress. A retardization of the magnetizing or demagnetizing effects as regards the causes which produce them. That quality of a paramagnetic substance by virtue of which energy is dissipated on the reversal of its magnetization.

I

Illuminated Track Diagram. See **Track Indicator.** See Figs. 2615, 2625-2629.

Impedance. The apparent resistance in an alternating current circuit containing both resistance and reactance. The total effect tending to retard the flow of current. The vector sum or square root of the sum of the squares of the resistance and reactance in such a circuit.

Impedance Bond. See **Inductive Bond.**

Impedance Coils. A term sometimes applied to choking coils, reactance coils, or economy coils.

In Advance of a Signal. The section of track occupied by a train that has passed a signal.

Indication. (1) The indication of a visual signal is what it tells the approaching enginemen. (2) In a power interlocking machine the indication is the electro-

magnetic or pneumatic action produced in the machine after a switch or a signal has been moved, indicating, by releasing a lock on one or more levers, that the switch movement or the signal movement actually has been completed.

Indicator. See **Block Indicator, Switch Indicator, Track Indicator, Signal Repeater.** See Figs. 2550-2674.

Induced Currents. Currents produced in a closed circuit by the effects of a changing magnetic field. Induced currents may be produced in one circuit by increasing or decreasing the current in a neighboring circuit, or by causing a closed circuit to cut a magnetic field.

Inductance. The capacity for induction of a circuit on itself or other circuits; self-induction—that property by virtue of which an electromotive force acting on the circuit does not immediately generate the full current which it is capable of producing in that circuit, and which when the electromotive force is withdrawn requires time for the current strength to fall to zero. The quality by virtue of which the passage of an electric current is necessarily accompanied by the absorption of electric energy in the formation of a magnetic field. A constant quantity in a circuit at rest and devoid of iron depending solely on its geometric arrangement. Inductance is usually expressed in henrys.

Inductance Coil. An impedance, reactance, or choking coil. A coil placed in a circuit, for the purpose of preventing an impulsive current-rush in that circuit, by means of the counter electromotive force developed in the coil on being magnetized.

Induction. The influence exerted by a charged body or by a magnetic field, on neighboring bodies without apparent communication. See **Induced Currents** and **Inductance.**

Induction Motor. A term usually applied to an a. c. motor having a short-circuited armature, and a stator wound to give the effect of a revolving flux, causing the rotor to be revolved by the force of attraction due to the induced currents in the short-circuited armature. See **Squirrel Cage Armature.**

Inductive Bond. In track circuits, a bond between contiguous rails of the track (the rails being insulated from each other by the usual non-conducting material between their ends), consisting of a coiled conductor, so arranged that the induction taking place in the coils, on the passage of an alternating current, will impede the flow of that current, while at the same time the passage of a direct current is not impeded. Thus the insulation in the joint is made of no effect as regards the direct current (used for propulsion of train), while it still is effective as regards the alternating current used for signaling. See Figs. 604-605, 639, 641, 643, 648, 653-655, 666, 671, and Figs. 2981-2982.

Inductive Track Bond. See **Inductive Bond.**

Inside Connected Facing Point Lock. See **Facing Point Lock,** and Figs. 1479, 1480.

Insulated Rail Joint. The term rail joint is used to denote the bars or plates and bolts used in a railway track to fasten together the ends of contiguous rails. An insulated joint is one in which a non conducting body (fiber), about ¼ in. thick, called an *end post,* is placed between the ends of the rail, and plates or strips of the same material around the bars and bolts so as to prevent electric current from passing from one rail to the other. Fiber plates placed below one or both of the rails are called mats or sole plates. Sometimes wooden blocks, called wooden fillers, are placed against the rails in place of or in addition to the iron bars. Insulated rail joints are used at the ends of track circuits. See Figs. 3628-3644.

Insulated Switch Rod. A rod, connecting the two rails of a switch in a railway track, which is divided into two parts, and the parts held together by a substance which is a non-conductor of electricity. Used in switches, the rails of which are traversed by electric circuits. See Figs. 3653-3654, 3659-3660, 3675-3677, 3680-3688.

Insulation. The protection of electrical conductors from other conducting substances and from the ground. See **Wires.**

Interlocking. "An arrangement of switch, lock and signal appliances so interconnected that their movements must succeed each other in a predetermined order." (A. R. A.) The term includes the tower, the machine, the switches and signals and all the connections and appurtenances. See **Interlocking Plant.**

Interlocking Machine. An assemblage of switch levers and signal levers, in a frame, with connections so arranged that the movement of a lever, or its unlocking, preparatory to its movement, may be made to lock any or all other levers in the frame. The interlocking is used to insure the movement of levers always in a predetermined order, thus preventing the giving of a conflicting or dangerous signal indication by mistake or inadvertence. The most common form of interlocking machine is the Saxby & Farmer, Figs. 790-850. Others are the Johnson, Figs. 903-932; the "Standard," Figs. 851-902; the National, Figs. 933-1003; the Stevens, Fig. 1006, and several dwarf machines, Figs. 1004-1005. Machines in which switches and signals are moved by hand-power (called "mechanical") have latch locking, which see. See **Power Interlocking Machine,** pages 210-279.

Interlocking Plant. A group of interlocking functions controlled from one interlocking machine, the machine and all its accessories. See **Interlocking,** pages 134-296; Figs. 740-2088.

Interlocking Relay. Two relays on a single base, so arranged that the armature of one can be made to lock that of the other, either, in its closed or its open position. See Figs. 2119-2145.

Interlocking Station. A place from which an interlocking plant is operated; usually a cabin or tower (see Figs. 3884-3908), the principal room being that occupied by the signalman and containing the interlocking machine.

Intermittent Current. A current that does not flow continuously, but which flows and ceases to flow at intervals, so that electricity is practically alternately present and absent from the circuit.

Ionize (verb). To break into ions. Ions are electro-positive particles of matter smaller that atoms. See **Mercury Arc Rectifier.**

Ions. The groups of atoms or radicals into which a molecule is separated by electrolytic decomposition.

J

Jaw. A forging attached to a pipe line for connecting it with the machine or with a crank, a compensator, or any other device. See Figs. 1026-1121.

Johnson Interlocking Machine. An interlocking machine with the locking bars and tappets arranged in a vertical plane beneath the floor. See Figs.

903-932. This style was first made in America by the Johnson Railroad Signal Company in 1889.

Jump Spark. A disruptive spark obtained between two opposed conducting surfaces, as distinguished from a spark obtained by or following a wiping contact.

Jumper. A temporary shunt or short-circuit in a series connected circuit. Commonly used in track circuit work to preserve the continuity of the track circuit past a section of track such as a crossing or electrified tracks where the wires cannot be suitably insulated.

Junction Box. A box to which are run a number of electrical conductors for convenient connection, disconnection, inspection, or change of connections. See Figs. 3701-3883.

K

K.W. Abbreviation for Kilowatt.

Kilowatt. Commonly abbreviated to k.w. One thousand **Watts,** which see. The common unit of rating for the output of electric generators. One horsepower equals .746 k.w.

Kilowatt Hour. The common unit of work as applied to electrical machinery, equal to the expenditure of one kilowatt for one hour.

Knife Switch. A common form of switch for making or breaking an electrical circuit, consisting of a blade like the blade of a knife, which may be pushed between two spring contacts. It is pivoted at one end, and has a non-conducting handle. Single or multiple blades may be used, all attached to the same handle. A switch may be either single or double throw. See Figs. 2504, 2508, 2510.

L

Lag. The phase difference of one alternating current behind another or of one function of an alternating current behind another function, as current and voltage.

Lagging Current. A periodic current lagging behind the impressed electromotive force which produces it.

Laminated Core. An iron core that has been subdivided in planes parallel to its magnetic flux-paths, in order to avoid the injurious production of Foucault or eddy currents.

Lamination. The sub-division of an iron core into laminae.

Lamp Signal. A common form of lamp for fixed signals is a rectangular sheet metal case, with a magnifying lens on the front side, and, if needed, a small glass-covered opening on the back side to enable the signalman or inspector to know whether the light is burning. The light may be secured from kerosene, acetylene, gas, or electricity. For signals, such as clockwork signals, which turn on a vertical spindle or shaft, the lamp has lenses on all four sides, two opposite each other, giving the clear indication and the two others opposite to each other giving the stop indication. See **Long-Time Burner; Back Light.** See Figs. 2675-2743.

Lampman. The person who cleans, fills and cares for the lamps of signals. Ordinary lamps are usually lighted and put in position each afternoon and taken down and extinguished each morning. Lamps with "long-time" burners remain in place, lighted, continuously for several days and nights.

Lantern. A cage or body surrounding, protecting and equipped with a lamp or other source of illumination. See Figs. 2675-2743.

Lap Sidings. On a single-track railway, an arrangement of two side tracks the ends of which overlap each other. Siding A being west of the station. on the south side of the main line, and siding B east of the station, on the north side, track A is continued a short distance east of the station and track B a short distance west of it. Thus if two freight trains are held at the station to clear the main line for a passenger train, the eastbound freight on track A and the westbound on track B, it is practicable for both of them, immediately after the passage of the passenger train, to proceed on their journeys without either delaying the other.

Latch Locking. Interlocking of one lever with another by means of the latches of the levers; necessary in mechanical interlocking to effect preliminary locking. In grasping a lever preparatory to moving it the signalman unlatches it, and in so doing locks all conflicting levers before his lever moves. Other levers intended to be released after this lever movement is effected are unlocked by the return of the latch to its notch after the lever has completed its stroke. See Figs. 790-1003.

Lazy-Jack Compensator. See **Compensator.**

Lead. The phase difference of one alternating current ahead of another or of one function of an alternating current ahead of another function, as current and voltage.

Leading Current. An alternating-current wave or component, in advance of the electromotive force producing it.

Lead Out. In an interlocking plant the pipes, wires and chains, and their supports and accessories, in and near the tower which *lead out* from the tower to the switches, signals, etc. See Figs. 1007-1020.

Lever Locking. The locking of interlocking switch or signal levers by the movement of levers, as distinguished from latch locking, which see.

Lightning Arrester. A device to prevent or reduce damage to electrical apparatus from discharges of lightning. Lightning is a high potential alternating current. It therefore tends to jump across short gaps especially from one metallic point to another; also it has difficulty in flowing through a coil, on account of the high self-induction. Lightning arresters are of two kinds—spark gap and impedance arresters. The former consists of two or more metallic plates, with tooth edges placed in close proximity to each other, one or more connected to ground, the others to the circuit to be protected. Impedence arresters consist of a coil of large-sized wire which checks the lightning discharge. Sometimes a ground plate is placed near the coil, so that the lightning may jump to it and thus reach ground. See Figs. 2744-2788.

Line Circuit. The wires or other conductors in the main line of a telegraphic or other circuit. A transmission circuit for electric energy.

Line of Force. A unit of measurement of the intensity of a magnetic field. It is purely imaginary, but of great convenience in electrical calculations. When so used it is always spoken of, in connection with the area of the field in centimeters. The current generated in the armature of a dynamo is said to be due to the fact that the armature coils cut the lines of force of the magnetic field, and the strength of the current is proportional to the number of lines of force cut per second.

Live Wire. A wire through which current is passing. A wire connected with an electric pressure or source.

Load-factor. The fraction expressed in per cent obtained by dividing the average load over any given period of time by the highest average load for any one minute during the same period of time.

Local Currents. A term sometimes used for eddy currents.

Lock and Block. A common name for the **Controlled Manual Block System,** which see. (Pages 27-45.)

Lock, Electric. An electro-magnetically actuated locking dog. The apparatus used to control a lever of an interlocking machine, switch or drawbridge. It is operated by an electric current. In interlocking machines it is usually applied to the lever latch movement. See **Indication.** See Figs. 2789-2812.

Lock Rod. A switch rod which receives the plunger of the lock. See **Switch; Facing Point Lock; Switch and Lock Movement.** See Figs. 1522-1527, 1532-1542, 3661-3662.

Locking. The rods, bars, dogs, tappets and other apparatus, in an interlocking machine, by which the interlocking is accomplished. See Figs. 790-1003.

Locking, Electric. The locking of the levers of an interlocking machine or of switches or drawbridges by electric locks (which see), or other means, to insure the integrity of a route, or portion of a route, during the movement of a train over that route. Electric locking is accomplished by controlling the current for operating the locks or other apparatus by track circuit relays or track instruments, or by circuit controllers actuated by signals, switches, drawbridges, etc. See Figs. 2055-2088.

Locking Bar. (1) A British term for detector bar, which see.

(2) A bar running lengthwise in the interlocking machine, to which the locking dogs are attached. See **Locking.**

Locking Dog. A variously-shaped block attached to a locking bar. Through it the interlocking is accomplished. See **Locking.**

Locking Sheet. A statement in tabular form of the locking operations which are provided for in a given interlocking machine. It shows the sequence in which levers must be locked or unlocked preparatory to giving clear signals for each route in the plant. See Figs. 747-788.

Locking Up Track Circuit. That track circuit used to take away unlock when train passes advance block signal into block ahead. It is located just beyond advance block signal.

Longitudinal Locking. That part of the mechanical locking apparatus which extends longitudinally in the locking frame. See Figs. 790-1004.

Long-Time Burner. A burner used in signal lamps, in which the wick, treated chemically so as to make it resist rapid combustion, may be so correctly adjusted as related to the lens and the reflector of the lamp that the flame of about 1 candle-power will burn continuously for from 100 to 150 hours. With lamps on high posts and scattered over miles of territory this affords a marked economy in attendance as compared with lamps needing to be trimmed or adjusted every day. See **Lamps, Lanterns,** etc., Figs. 2675-2743.

Lower Quadrant. One of the quarters of a circle below its horizontal axis; a term used of semaphore signals, in which the arm, normally horizontal (indicating stop), is turned downward to give other than stop indications.

M

M. P. F. Abbreviation for Movable Point Frog.

Machine (verb). To form by the aid of machinery.

Machine Framing. The frame in an interlocking cabin on which the interlocking machine rests; usually set on a foundation separate from that which supports the walls of the building. See Figs. 1011-1020, 3896-3897, 3905-3908.

Magnet. A body possessing the power of attracting magnetizable bodies like iron filings. Magnets have two poles called north and south, respectively. The north pole of one magnet will repel the north pole of another magnet, but will attract the south pole of a second magnet. A magnet is said to possess a magnetic field consisting of lines of force, which see. The lines of force are assumed in passing through the magnetic field to come out at the north pole and go in at the south pole. The lines of force form a closed magnetic circuit. If a magnetizable body is brought into a magnetic field, the lines of force are concentrated on it and pass through it. The body thereupon becomes magnetic by induction. See **Electro-Magnet.**

Magnet Coil. A coil of insulated wire surrounding the core of an electro-magnet, through which the magnetizing current is passed.

Magnet Cores. Bars or cylinders of iron on which the magnetizing coils of wire are placed.

Magnetic Clutch. A form of clutch in which magnetic attraction is substituted for ordinary mechanical force, to obtain the friction required in the clutch. A clutch operated electro-magnetically.

Magnetic Field. The region of magnetic influence surrounding the poles of a magnet. The space or region traversed by magnetic flux in which a magnet needle, free to move, will assume a definite position.

Magnetic Flux. The number of lines of magnetic force that pass or flow through a magnetic circuit; the total number of lines of magnetic force in any field. The magnetic flux is also called the magnetic flow. See **Line of Force.**

Magnetic Shading. Preventing magnetic induction from taking place by interposing a metallic plate or a closed circuit of insulated wire between the body producing the magnetic field and the body to be magnetically shaded; or by placing a small closed circuit in a part of the pole-piece of a magnet. See Figs. 680-684.

Magneto. A magneto-generator. A small magneto-electric dynamo machine.

Maintainer. The person in immediate charge of the maintenance of signals.

Manifest Train. A familiar term for designating the more important freight trains; those of which the manifests or waybills are specially recorded.

Manual Block System. A block system in which the block signals at a block station are moved by hand by an attendant, on information conveyed to him from adjacent block stations by Morse telegraph, needle telegraph, telephone or single-stroke electric bells sounded in accordance with a prescribed code. The term "manual" is used to distinguish such a system from the **Automatic Block Signal System,** which see, in which the signals are worked by mechanical or electrical power controlled automatically by the passage of a train into, through and out of a

block section. The **Controlled Manual Block System** which see, differs from the simple manual block system by the introduction of electric locking devices attached to the levers by which the signals are moved, so that to clear a signal admitting a train into the block, the simultaneous action of the signalmen at both ends of the block is required.

With the manual block system the blocks are made from 1,000 ft. to 10 miles or more long, and where the traffic is light the station agents at small stations, being telegraphers, act as block signalmen. The usual method of communication in the United States is the **Morse Telegraph** (which see), while in Great Britain the needle telegraph and electric bells are used. Each block station has two home signals, one to govern the movement of trains in each direction. On American single-track lines the arms for both directions are often placed on the same post. **Distant Signals** and **Advance Signals,** which see, are also frequently installed. All of these signals are moved by levers in the signal tower and stand normally in the stop position, being cleared only on the approach of a train, for which the block ahead is clear, and restored to the normal position after the train has passed.

Transcript of Part of a Block Signalman's Daily Record of Trains.

Eastward

TRAIN	Eng.	Da		Ki				Cn
		D	Track	Track	A	D	Track	D
70		209	1	1	215	217	1	221
66		446	1	1	—	450	1	455
	1561	450	2	2	—	505	2	—
14		503	1	1	—	507	1	511
	1060	515	2	2	—	522	2	—
78		526	1	1	—	531	1	536
10		601	1	1	—	605	1	608
	728	602	2	2	—	610	2	—
6		613	1	1	—	616	1	619
	1042	625	1	1	—	632	1	640

Note.—This is the record kept at Ki station. "Da" is the station next west and "Cn" is the station next east. This is for a four-track railroad. With a double-track line the track number would not be required.

Each signalman keeps a record of passing trains in the form substantially like that shown herewith for station Ki. The column Da shows the time trains were reported as leaving the next station to the west. The column Ki shows the time of trains arriving at and departing from this station, and the column Cn shows the time trains were reported as leaving the next station to the east.

On some roads the manual block system is used with a bell code in place of the telegraph. The following table gives the principal clauses of the code of signals adopted which cover most of the necessary information to be conveyed.

Rings.	Meaning.
1.	Acknowledgment of any signal except as noted.
2.	Yes.
3.	Is block clear? Answer by 2 or 5.
4.	Train has entered block.
5.	Block not clear.
2-1.	No.
2-4.	Has train cleared? Answer 4-2 or 5.
3-3.	Train is on siding clear of main track.
3-3-3.	Train to you broken in two. Answer by repeating 3-3-3 to sender.
4-2.	Track has cleared.
9.	Stop train. Has no markers.

See **Permissive Blocking, Absolute Blocking.**

Maximum Traffic on a Block Signaled Line. See **Block Signaling for Maximum Traffic.**

Mechanical Interlocking. The term is the general designation for the machine and the other apparatus at an interlocking plant where the switches and signals are moved by means of rods or wires by manual power; distinguishing such a plant from one in which compressed air or electricity is the force which moves the switches and signals. See pages 134-209; Figs. 740-1761.

Mechanical Trip. A term used to denote a trip—as used in apparatus for stopping trains without the intervention of the engineman—which is actuated or controlled by mechanical means, as distinguished from apparatus in which electricity or magnetism is employed.

Mechanism. Used as a general term for any mechanical or power-operated device for operating a signal or interlocking function or accessory device from a distance. More specifically used to refer to a signal mechanism. See Figs. 512-602. The operating device for a switch or derail is commonly termed a movement, which see.

Mechanism Case. The housing for a signal mechanism.

Megohm. One million ohms. See **Ohm.**

Mercury Arc Rectifier. See Figs. 2900-2915.

Mercury Contact Relay. A relay, the armature of which closes the local circuit or circuits by making a contact through mercury. See Fig. 3051.

Mil. A unit of length equal to .001 in., used in measuring the diameter of wire. See **Circular Mil.**

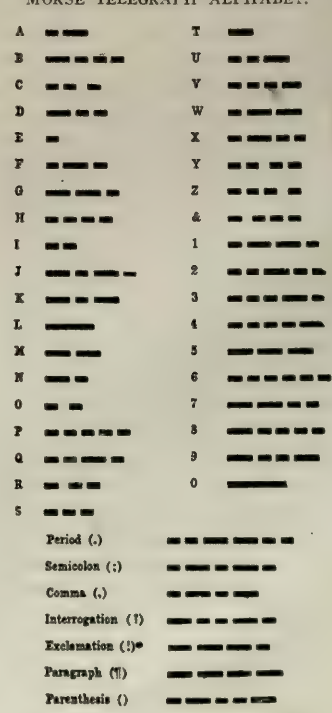
Mil-foot. A resistance standard consisting of a foot of wire, or other conducting material, one mil in diameter. A standard of comparison of resistivity or conductivity of wires.

Milli-ammeter. A milli-ampere meter.

Milliampere. The one thousandth part of an **Ampere,** which see.

Morse Alphabet. The arbitrary code of dots and dashes representing the letters of the alphabet used as the guide in making and breaking the telegraph circuit. The American code is given below.

MORSE TELEGRAPH ALPHABET.



Morse Telegraph. A method of communicating between two distant points by sending electric impulses over a wire, the circuit being made and broken according to the **Morse Alphabet,** which see. The signals thus formed are received and made audible by an electro-magnetic sounder or receiver. Invented in 1837 by S. F. B. Morse. First used publicly in 1844. See **Needle Telegraph.** See Figs. 3546-3548.

Motor, Electric. A device for transforming electrical power into mechanical power. All practical electric motors depend for their operation on the tendency to motion in a magnetic field of a conductor carrying a current or on magnetic attraction or repulsion. The entire magnetism may be produced by the current, or part may be obtained from permanent magnets and the rest from electro-magnets (Houston). See Figs. 531-532, 544, 558, 572, 2860-2866, 2869-2870, 2886-2887.

Motor-generator. A motor coupled to a generator. See Figs. 2861, 2863, 2864-2866, 2869-2870, 2886-2887. A motor-dynamo. A transforming device.

Movement. Common term applied to the mechanical or power-operated device for moving a switch, derail, detector bar or other device in the track, from a distant point.

Multiple (Electricity). Two or more pieces of electrical apparatus, such as batteries, indicators, lamps, motors or contact points, are said to be connected in multiple when they are connected across two mains leading from the source of supply. A part of the current flows through each lamp, motor or other function. Pieces of apparatus thus connected are also said to be connected in parallel.

Multiple Circuit. A circuit in which a number of separate sources or separate receptive devices, or both, have all their positive poles connected to a single positive lead or conductor, and all their negative poles connected to a single negative lead or conductor.

Multiple-series Circuit. A circuit in which a number of separate sources, or receptive devices, or both, are connected in a number of separate groups in series, and these separate groups subsequently connected in multiple.

N

National Interlocking Machine. An interlocking machine having vertical locking arranged in a frame below the floor. Originally made by the National Signal Company. See Figs. 933-1003.

Needle Telegraph. An apparatus by which signals transmitted from one point are received at the other end of the line by observing the movements to the right or left of a vertical needle over a dial. The single needle apparatus of Wheatstone consists of an astatic needle mounted inside a double coil of fine wire connected to the external circuit and free to rotate on a horizontal axis, carrying on its end the pointer, projecting through the dial. The needle is made to turn to the right or left by reversing the direction of the current flowing through the coil and the external circuit. The sender consists of a double key or tapper. Depressing one key sends a negative current through the line and turns the needle to the right. Depressing the other key sends a positive current from the battery through the line and deflects the needle to the left. The movement of the needle to the left indicates a dot in the **Morse Alphabet,** which see, and a move to the right indicates a dash. In Great Britain the needle telegraph is used in manual block signaling between adjoining signal cabins. An elaborate bell code is usually used in conjunction with it. See **Morse Telegraph.**

Neutral Relay. An ordinary direct current electromagnetic relay, workable by a direct current, regardless of the polarity of the current. See Figs. 3044-3075, 3078.

Night Signal Colors. Uutil within a few years the general practice with signal lights throughout the United States was *white* (an ordinary oil-lamp flame) for clear or proceed, *green* for caution (both for permissive block signaling and for the adverse indications of distant signals), and *red* for stop. Since 1899 the green-yellow-red system has gained favor; *green* for clear or proceed, *yellow* for adverse distant and *red* for stop. In Great Britain green has been the "clear" color universally for 15 years or more; but yellow is not used, as in that country distant signals usually have the same night colors as home signals. On the Chicago & North-Western for many years green has been the "clear" color, and the adverse distant signal is given by a green and red light side by side. A number of roads have abandoned red as the stop indication in dwarf signals and have substituted purple or blue. These colors are practicable at the short distances which dwarf signals have to be seen. See Figs. 229-276.

Normal. The position in which a lever in an interlocking machine stands when the corresponding switch or signal is in its normal position. A switch is "normal" when set for the main track; a derailing switch is normal when set to derail; a home signal when it indicates stop; a distant signal when it indicates caution. Automatic block signals in their simplest form are called "normal clear," as at all times when their block sections are unoccupied with the switches closed and all apparatus in order the home signals stand at "clear," indicating "proceed." In a modified arrangement, called "Normal Danger," the home signals indicate "stop" at all times (even when the block is clear), except when a train is approaching, and then they indicate "proceed" only in case the block is clear. The practice thus resembles the practice in manual signaling, where home signals are always kept in the stop position except when it is necessary to clear them for the passage of a train. On a double-track or a four-track railway the normal movement of trains, on a given track, is that in which trains regularly run on that track. By special order of the train dispatcher trains may be moved in the opposite direction against the "current of traffic."

O

Off. In operating signals, a two-position semaphore signal, when in the position indicating proceed (either at full speed, as at a home signal, or otherwise, as at a distant signal) is said to be "off." When in the other position the signal is said to be "on." This term is common in Great Britain, but not common in America.

Ohm. The unit of electric resistance. Such a resistance as would limit the flow of electric current under an electromotive force of 1 volt to 1 ampere. The standard of measurement is the resistance of a column of pure mercury 1 square millimeter in cross-section and 106 centimeters long at a temperature of 0 deg. Cent. or 32 deg. Fahr.

Ohmmeter. An instrument for measuring directly in terms of ohms unknown resistances. See Figs. 3539-3541.

Ohm's Law. The expression $I = \frac{E}{R}$ is commonly called Ohm's law. It shows the relation between current, voltage and resistance in a D.C. circuit or an A.C. circuit containing no inductance or capacity. It may be expressed as

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}},\ \text{Ohms} = \frac{\text{Volts}}{\text{Amperes}},\ \text{or Volts} = \text{Amperes} \times \text{Ohms}.$$

See **Ampere.**

Oil Crank Box. A water-tight box, in which a crank is pivoted. It is filled with oil and used in connection with oil pipes, which see. See also Figs. 1425-1444.

Oil Pipe. A pipe within which a wire or a second pipe for the operation of an interlocking function is laid where it must run underground, as at a highway crossing. After the insertion of the operating pipe or wire the remaining space is filled with oil to reduce friction and exclude moisture. Stuffing boxes are provided at each end to prevent the escape of the oil. See Figs. 1421-1444.

Oil Transformer. A transformer immersed in oil in order to insure and maintain high insulation. An oil-insulated transformer.

On. In operating signals, a two-position semaphore signal, when indicating *stop* (as at a home signal) or *stop at the home signal* (as at a distant signal), is said to be "on." This term is common in Great Britain, but not in America. See **Off.**

Open Circuit. A term used to designate an electric circuit normally broken at one or more points; as, for example, the ordinary door-bell circuit, which is always open at the push button except when a contact is completed at that point, by pressing the button, to close the circuit and energize the magnets of the bell. If the wire of this circuit should be broken at any point, the closing of the circuit at the button would fail to ring the bell, and the person pressing the button would be ignorant of the failure. In railway signaling such a condition would introduce an element of danger. See **Closed Circuit.**

Open Switch. Set so as to turn trains away from the main track; said of outlying switches when set for the sidetrack. At interlockings, where switches are constantly under the charge of an attendant, the term is inappropriate, as all such switches are suitably safeguarded by signals; but it is used everywhere to describe a derailing switch which is set to turn trains off the track.

Operated Unit. In interlocking this term is used when speaking collectively of switches, signals, movable frogs, derails and any other apparatus worked or controlled by levers in the machine. For example, a machine from which are worked 10 switches, 5 locks and 10 signals is said to control 25 units. The American Railway Engineering Association has declared each of the following to be one unit: One signal arm; one pair switch points; one derail; one pair movable frog points; one 50-ft. detector bar, with lock; one lock; one scotch block; one torpedo machine; one electric lock; one annunciator or indicator for one route. A committee of signal officers of the New York Central Lines has adopted these values, except that a detector bar without lock is valued at ½ and a lock (of a detector bar) at ½. A value of 1 is given also to one detector circuit per switch.

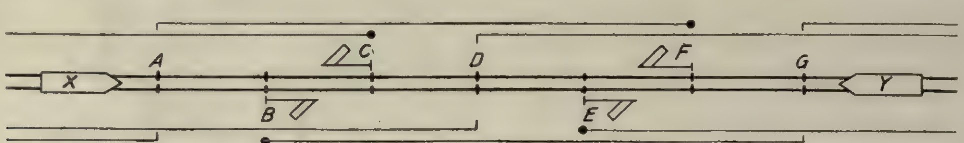
Operator (Telegraph). On those American railways where the "telegraph block system" is used and where it is worked by persons whose principal occupation has been, and perhaps continues to be, telegraphing, the old title continues in use, and the terms, "operator" and "signalman," are used indiscriminately.

Outlying Switch. A switch not connected with an interlocking plant. Such a switch may be locked by a key which is kept by the nearest signalman, or by a lock controlled from the nearest signal tower by an electric connection. In some cases where neither of these arrangements is in force telephone communication is maintained between the switch and the nearest signal tower, so that trainmen using the switch can receive from the signalman instructions as to the use of the main track.

Outlying Switch Lock. An electric switch lock, which see, applied to an outlying switch, which see.

Outside Connected Facing Point Lock. See **Facing Point Lock.** See also Figs. 1481-1483.

Overlap. An arrangement of track circuits for block signals, originally introduced as a substitute for distant signals. With a block section extending from A to B a track circuit for, say, 2,000 ft. beyond B is arranged, so that when it is occupied by a train (or car) the signal at *A* will be held in the stop position, the same as though the train were between A and B. Thus, when signal A is cleared, a train passing it is not only assured of a clear track to B, but also is assured that signal *B* may be overrun 2,000 ft. without danger of collision with the preceding train. Where a line is fully equipped with distant signals, so that enginemen will never need to slacken speed to make sure of the indication of the home signal before passing it, the overlap is generally deemed unnecessary, and it is used with distant signals only on a few lines—the New York Central electrified lines and the Interborough (New York) subway express tracks being the most prominent. Both in these situations and where used without a distant signal, and as a substitute for it, the overlap is criticised because it tends to impair discipline, its presence suggesting that a signal indicating "stop" (at that signal) need not be strictly obeyed. In the New York subway (Interborough) and on the electrified lines of the New York Central, where overlaps and distant signals are both used, the overlaps are in most cases the full length of the block sections. In the subway this means about 900 ft. On single track lines,



Arrangement of Overlaps for Automatic Block Signals on a Single Track Line.

automatic block signals are arranged with overlaps, so as to prevent the occurrence of a collision between trains moving toward each other, which without the overlap might pass clear signals at the same moment. The opposing signals are so situated that each train will encounter a stop signal before it can meet the other. The diagram herewith shows a typical arrangement of automatic block signals on a single-track road. Signal B is controlled by track circuits to the point G and Signal F, similar to A. Suppose two approaching trains, to be represented by X and Y. Assume train Y to pass F at clear at the same instant that train X passes point A. Train Y would set signal B at stop and train X would set signal C; and the trains would be held at signals C and B, respectively. If the track sections were arranged so that train X could pass signal B at clear and Y pass F at clear at the same instant, Y might possibly be stopped at C, but X, having a clear signal at B, would continue on through the block and collide with Y. In the positions shown the two trains would set signals C and E at stop. See Figs. 312, 324, 486, 489, 495, 498, 653, 675, 686-688.

Overstroke. Excess throw in a pipe or wire line.

P

Pan Copper. A copper element of peculiar shape used in gravity batteries. See Figs. 2306-2308.

Parallel. (Applied to electric circuits.) See **Multiple.**

Parallel Bar. A British term for **Detector Bar,** which see.

Period. The interval of time between two successive passages of a vibration through a given point of its path taken in the same direction. The time occupied in performing a complete cycle.

Permanent Magnet. A name sometimes given to a magnet composed of hardened steel, whose magnetic retentivity is high.

Permissive Block Signaling. Permitting one or more trains moving in the same direction to enter a block section before the last preceding train has passed out at the other end. In such cases the following train is allowed to proceed, expecting to find the track blocked, and prepared to stop before reaching any obstruction, without being warned by a flagman or otherwise. Permission to proceed is given by a written card from the signalman; or by signal indication (the intermediate position of a three-position signal) or by flag or hand lantern. In automatic block signal systems the practice generally is permissive, for if a signal were out of order and indicating stop the line would be blocked until the signal could be repaired. The most common rule where automatic signals are used is to stop at a signal indicating stop, wait one minute and then proceed through the block with speed under control. On those lines of the New York subway which have automatic block signals, and in a few other places, trains are forbidden to pass a stop signal without first sending a flagman ahead. On single track roads with automatic signals it is the rule to send a flagman ahead. After waiting long enough for him to go a safe distance, the train proceeds at low speed under his protection. He must be sent forward at once, because it is impossible to know whether the stop indication is due to a failure of the apparatus or to the presence in the block of an opposing train. On the Cincinnati, New Orleans & Texas Pacific, and several other roads, the passenger trains are provided with light track velocipedes, carried in the baggage car for use in flagging ahead.

With the manual block system permissive blocking is an expedient to obviate the expense of maintaining short block sections and is ordinarily allowed only with freight and work trains, absolute blocking being enforced before and behind passenger trains. See **Caution Card.** For common arrangements of permissive block signals see Figs. 316-317. With controlled manual signals, permissive blocking is usually forbidden, as the "control" attachments would be made useless.

Permissive Card. See **Caution Card.**

Phase. The fractional part of a cycle of an alternating current which has elapsed since the current last reached its maximum positive value.

Pipe Carrier. A grooved roller supported in suitable bearings. In a mechanical interlocking, a series of pipe carriers is used to support a line of pipe for operating a switch or signal. Where only one roller is used it is called a one-way pipe carrier; two rollers, a two-way carrier, etc. A small top roller is frequently used to keep the pipe in place in the grooved roller. See Figs. 1205-1233, 1240, 1242-1258, 1267-1268.

Pipe Carrier Stand. A casting carrying the grooved rollers of a pipe carrier and bolted to the foundation. See **Pipe Carrier.**

Pipe Compensator. A device for automatically compensating for the changes in the length of a pipe line due to temperature changes. Such a device is necessary in long pipe lines in order to preserve a uniform range of movement at the end connected to the switch or signal. The simplest form consists of a straight lever pivoted at the center and having one section of the pipe attached to one end and the adjoining section to the other end. If one or more compensators are placed between the leadout and the outlying end of the pipe line, each in the middle of the section of pipe to be compensated by it, the only effect of changes of temperature will be to change the angle of the compensating lever. In order to keep the pipe in a straight line a form of self-contained double compensator called a **Lazy Jack,** which see, is most frequently used. Where a line of pipe changes direction, the crank at the angle can be arranged to serve as a compensator. See **Compensator.**

Pipe Coupling. See **Pipe Plug.** See also Figs. 1026-1030.

Pipe Line. The common name for the line of rodding which connects a switch or signal to its lever, such rodding being usually made of one-inch wrought iron or steel pipe. In Great Britain rods of L shape are used extensively. See Fig. 1010.

Pipe Line Lug. See Figs. 1031, and 21, 22, 23, 26, 27, 28, Figs. 1047-1121.

Pipe Plug. A piece of round iron rod, used to stiffen pipe at a joint. It is used in addition to the pipe sleeve and is riveted to the pipe. See Figs. 1026-1027.

Pipe Run. In an interlocking plant, an assemblage of pipe lines, with their carriers and foundations in a common course. See **Pipe Line.**

Pit. A depression below the floor level of an interlocking tower in which the leadout apparatus is situated.

Plunge (verb). In controlled manual block signaling, the operation which is required to release the sig-

nal lever at the distant station. See **Controlled Manual,** pages 27-45, Figs. 346-405.

Plunger. The handle or other operating device of the "lock and block" instrument. The term is also applied to the bar which effects the locking in a facing point lock. See Figs. 346-405.

Plunger Box. The casting or guide in which the plunger of a bridge bolt lock moves.

Plunger Casting. A stand and guide for facing point and bridge lock plungers and lock rods. See Figs. 1467-1478, 1736-1738, 1747-1749, 1753-1757.

Plunger Lock. See **Facing Point Lock.** See also Figs. 1467-1478, 1736-1738, 1747-1749, 1753-1757.

Plunger Release Track Circuit. That track circuit by means of which plunger of block instrument is released. Operates in conjunction with circuit controller of home lever and circuit controllers operated by arms of distant and home signals to effect release of plunger of block instrument after whole train has passed home signal and home signal is locked in normal position, home signal indicates stop and distant signal caution. So located that train passing through block station limits will not pass off plunger release track until whole train has passed home signal.

Pneumatic Interlocking. Interlocking apparatus in which both the power to work the switches and signals and the instrumentalities for controlling that power from the cabin are actuated by compressed air. In the older electro-pneumatic apparatus the switches and signals are worked by compressed air, but the air valves are controlled from the tower electrically. See Figs. 1955-2040.

Point Lug. A lug bolted to the web of a switch point, to which the switch rods are attached. See Figs. 1486-1512.

Point Rail. In a "split" switch, either of the two movable rails, pointed at the movable end, as distinguished from the immovable "stock" rails.

Point Separator. A device for spacing the inner points of a double slip switch in relation to each other. Used in place of a switch point lug, which see.

Polarized Relay. A direct current relay, having a permanently magnetized ("polarized") armature which responds to changes in the polarity of the electromagnet, resulting from changes in the direction of the current flowing in the magnet coils. Contacts carried by the polarized armature close a local circuit when the armature moves to one position under the influence of current in one direction in the magnet coils and open such circuit when current flows in the opposite direction. See Figs. 700, 3075-3077, 3079-3080, 3085-3092, 3096.

Polarized Track Circuit. See **"Wireless" Automatic Block Signal System.**

Pole Changer. A double-pole, double-throw switch so connected that the alternate positions effect a change in the direction of the current in the connecting wires. In block signaling it is attached to and worked by the home signal, for reversing the polarity of the track circuit of the section in the rear, by changing the connection from the battery to the line. This is done to control the distant signal in the rear, through the track circuit, thus obviating the need of a line wire for such control. See Figs. 529-530; P, Fig. 537.

Pole-piece. That part of the core of an electromagnet which projects beyond the coil and near which the armature is placed. Often in the form of a block attached to the core. Used to concentrate the lines of force.

Polyphase. Possessing more than a single phase.

Polyphase Currents. Currents differing in phase from one another by a definite amount, and suitable for the operation of polyphase motors or similar apparatus.

Polyphase Relay. A relay designed to respond to polyphase alternating current. See Figs. 656-657, 696.

Portable Batteries. A portable battery consists of one or more cells mounted conveniently as a unit for handling. The number of cells should be limited by the maximum weight desired. If the number of cells in one unit is not sufficient to obtain the working voltage, additional units are connected in series. The size of the cell is determined as in stationary battery. The plates should be of minimum weight consistent with reasonably long life. They are assembled in groups and elements, and mounted (in a suitable container), so as to reduce chance of breakage to a minimum. There should be no metal connections other than lead exposed in order to prevent corrosion from acid. All metal connections should be so arranged as to reduce corrosion from acid.

Post. See **Signal Post; Bracket Post.**

Note.—Post, pole, bracket mast, mast.—Post, is used to define the vertical member of a semaphore signal, because it supports something. Pole means a slender piece of timber, implying inability to support a load. Bracket mast is used to define the upper vertical members of a bracket signal, particularly that one of those members which carries no arm and merely aids in making clear the position and meaning of the others. Mast is used in the codes of the American Railway Association to define the post (as in a bracket post signal), to which the arm is attached, in distinction from the single post, set in the ground, supporting two or more "masts." See Figs. 279-307.

Pot Signal. A low revolving signal, turning on a vertical axis and used either as a switch target for indicating the position of the switch (to which it is attached) or as a dwarf signal for low-speed movements. Now generally superseded as a dwarf signal by the **Dwarf Semaphore,** which see. It consists of a lamp having either two or four lenses, two lenses being used for dwarf signals and four lenses for switch targets. The faces of the lamp, usually made as flaring disk, are painted corresponding colors to the lenses, and these colors give the day indications. Signals thus turning on a vertical axis are used in some tunnels and yards where there is not room for a semaphore. See **Night Signal Indications.** See Figs. 1666-1667, 1682-1683, 1687-1691.

Potash Battery. A primary battery using caustic potash solution for the electrolyte and having copper oxide for the positive element and metallic zinc for the negative element.

Power. Rate-of-doing-work, expressible in watts, joules-per-second, foot pounds-per-hour, etc. Activity.

Power Factor. The ratio of the true watts to the apparent volt-amperes in an alternating current conductor, circuit, or device. It equals the cosine of the angle of lag of the alternating current.

Power Interlocking. Interlocking apparatus operated by some form of power other than manual, usually electricity or compressed air or a combination of

the two. See **Power Interlocking Machine** and Figs. 1762-2054.

Power Interlocking Machine. An **Interlocking Machine,** which see, in which the levers for moving switches and signals by manual power are supplanted by levers, or sliding bars, for convenience, called levers, which merely close or open electric circuits, or in the all-air machine open or close air-valves. In the "electric" system the electric power moves the switches and signals. In the electro-pneumatic compressed air moves the switches and signals, and the air valves are worked by electro-magnets controlled from the interlocking machine. See Figs. 1762-2054.

Preliminary Locking. Interlocking so arranged that the locking of a lever, to prevent it from being moved in conflict with another, which is about to be moved, is fully effected before that other lever begins to perform its function. In mechanical interlocking this is **Latch Locking,** which see. In power machines the "levers" are so arranged that the lever by a single stroke does three things: In its first part the locking of conflicting levers; in its second the performance of its own main function (causing the movement of a switch or signal), and in its third the unlocking of other levers which then may properly be moved.

Primary. That winding of an induction motor or of a transformer which directly receives power. The term is to be preceded, in the case of transformers, by the words "high voltage" or "low voltage," in the case of induction motors by "rotating" or "stationary."

Primary Battery. More properly primary cell. Any combination of two metals or metalloids, which when immersed in a liquid termed an electrolyte, and connected outside the liquid by a conductor, will produce a current of electricity. A large number of such cells employing different elements and electrolytes are in use. The action in a primary cell is electro-chemical, the electrolyte being decomposed by the passage of the current and attacking one or both of the elements. In the cell the current flows from the metal most acted on to the metal least acted on. In a zinc and copper cell with dilute sulphuric acid as the electrolyte, for example, the current flows through the liquid from the zinc to the copper. In the external circuit the direction is, of course, the opposite and the zinc electrode is negative, while the copper electrode is positive. The most usual combinations of elements are (1) zinc and carbon and (2) zinc and copper. See **Storage Battery; Gravity Cell.** See Figs. 2297-2351.

Pulling Wire. The wire attached to the front tail lever of an interlocking machine which pulls a signal clear. See **Back Wire.**

Push Button. A device for closing an electric circuit by the movement of a button.

Pusher. A locomotive used to push a train up an ascending grade, usually co-operating with another engine attached in the regular way to the front of the train. The pusher is detached at the top of the grade; and as that point may be between block stations special block signal arrangements are sometimes prescribed to permit the pusher to back down on the same track to the point from which it began the ascent. See **Electric Train Staff System.**

Pusher Attachment. An attachment to electric train-staff apparatus, designed to protect, in addition to the regular train movement, the movement of a pushing engine when, after being detached from the rear of the train, it is to be run back to its starting point. See **Electric Train Staff System,** also see pages 27-45.

R

Radial Arm. See Figs. 1185-1204.

Rail. The continuous line of rails constituting one side of a track. Contiguous rails are spoken of collectively as the left hand or right hand rail of the track.

Rail Bond. A wire, or wires, about two feet long, used to connect the adjacent ends of contiguous rails, in a track, to insure the continuity of that line of rails as an electrical conductor. Thus, in a track circuit of, say, one mile in length, each of the two lines of rails constituting that track is a conductor one mile long. In a new track the bars and bolts fastening two rails together may serve as an electrical bond, but they are not to be depended on. See Figs. 3594-3627.

Rail Brace. An iron block or frame, against which the web of the rail may rest. Used to take side thrust at switches and thereby maintain the gage of the track. Usually held in place on the tie plate by lag screws or spikes and a butt strap or projection on the plate. See Figs. **1485, 1529-1530.**

Rail Clip. A metal support bolted or clamped to a rail for carrying a detector bar through suitable connections. See Figs. 1568-1611.

Railway, Electric. See **Electric Railway.**

Ramp. In cab signaling or train stopping systems, a bar with an inclined upper surface fixed on the ties of the track and designed to lift a vertically moving member depending from a passing locomotive. For example, a ramp might be fifty feet long, with its near end about three inches lower than its far end. Thus the lifting will be effected at moderate speed, avoiding shocks, even if the speed of the engine is high.

Reactance. In an alternating current circuit the component of impedence, or total effect retarding the flow of current, which is out of phase with or 90 deg. from the phase of the current. The ohmic effect due to the induction in the circuit. See **Resistance** and **Impedance.**

Reactance Bond. See **Inductive Bond.**

Reactance Coil. A coil for producing difference of phase or for eliminating current. A magnetizing coil surrounded by a conducting covering or sheathing which opposes the passage of rapidly alternating currents less when directly over the magnetizing coil than when a short distance from it. A choking coil or reactor.

Rear. As used to define signals, one which is back of another, as related to the train for which such signal is used. A distant signal is in the rear of (not in advance of) a home signal.

Rear Collision. A collision in which a train (or engine) collides with a train, car, or engine ahead of it, headed in the same direction as itself.

Rectifier. See **Mercury Arc Rectifier.**

Relay. In its most common form, an electromagnet designed to repeat the effects of an electric current in a second circuit. For example, in a telegraph line, the relay is energized by the comparatively

weak current of the line, and its armature, being thereby attracted, by suitable contacts mounted on it, closes the strong local circuit. In a track circuit, the relay, delicately adjusted to close its armature on the passage of the weak current of the track circuit, closes the strong local circuit which works or controls the signal. A relay having an armature bearing a number of contacts can be made to close as many different local circuits. When the armature of a relay is attracted, it closes a front contact; when the coils of the magnet are de-energized and the armature falls away by gravity or is drawn away by a spring, it closes a back contact. See Figs. 3044-3103. See **Interlocking Relay, Neutral Relay, Mercury Contact Relay.** For other kinds of relays see **Alternating Current Relay, Frequency Relay, Polarized Relay, Polyphase Relay, Vane Relay.**

Relay Post. A post set in the ground to support a relay box.

Repeater. See **Signal Repeater.**

Repulsion Motor. An electric motor deriving its power from the repulsion between electric charges. An alternating current motor deriving its power from the repulsion between electric currents. An alternating current motor in which the armature is provided with temporarily short-circuited windings by means of a commutator and brushes.

Residual Magnetism. The magnetism remaining in a core of an electromagnet on the opening of the magnetizing circuit. The small amount of magnetism retained by soft iron when removed from any magnetic flux.

Resistance. That which opposes or retards the passage of an electric current. In a direct current circuit the resistance, according to Ohm's Law, is the ratio of the electromotive force which causes the current to flow and the current so produced. $R = \frac{E}{I}$. In an alternating current circuit resistance is the component of impedance or total retarding effect which is in phase with or parallel to the current. The unit of measurement of resistance is the **Ohm,** which see. The following table gives the relative resistance of several of the most widely used metals and of carbon, as compared with silver, the best conductor known:

Silver	1.00
Copper	1.063
Gold	1.369
Aluminum	1.935
Zinc	3.741
Platinum	6.022
Iron	6.460
Lead	13.05
German Silver	13.920
Mercury	62.73
Graphite	750.00
Coke Carbon	6250.00

Resistance Grid. See **Resistance.** Figs. 678-679.

Reverse (verb). To reverse a mechanical signal lever is to move it from its normal to the opposite position. In the electro-pneumatic machine signal levers have three positions. The central position is normal and the lever is moved to the right to control one signal and to the left to control another.

Rheostat. An adjustable resistance. See Figs. 678-679.

Riser Plate. An iron plate riveted to the **Tie Plate,** which see, at a switch and used to support the switch points. Sometimes called a slide plate.

Rocker Shaft. See Figs. 1010-1015, 1279-1292.

Rocker Shaft Leadout. See Figs. 1010-1015.

Rotary Converter. A secondary generator for transforming alternating into continuous currents or vice versa, consisting of an alternating current machine whose armature winding is connected with a commutator.

Rotor. The rotating member, whether primary or secondary, of any alternating current machine.

Roundel. A round, flat piece of glass, as the colored glasses used in semaphore signals.

Route. A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, as in a yard; or any one of several possible combinations of turnouts or crossovers by which a train may travel from one place to another.

Route Locking. The electric locking of switches drawbridges, etc., in a route, or the signals of a conflicting route, to maintain the integrity of a route during the movement of a train over that route. Route locking may take effect upon the clearing of the signal governing the route and maintain the integrity of the route from that time until a train has passed over the route. See **Electric Locking, Track Circuit Locking.** See Figs. 2055-2088.

S

S. L. M. Abbreviation for Switch and Lock Movement.

S Armature. See **Z Armature.**

Saxby & Farmer Interlocking Machine. The most common form of mechanical interlocking machine in use in America. See Figs. 790-850.

Schedule. See **Time Table.**

Scotchblock. A block of wood or metal to be fastened on one or both rails of a track, as at the outlet of a siding or turnout, designed to throw off the track any car accidentally running from the siding to the main track when unattended or at a time when such a movement would possibly lead to a collision. See **Derail.**

Screw Jaw. A jaw fastened by a screw so as to be adjustable. See Figs. 1047-1133.

Screw Release. A device for releasing an electric lock (in a mechanical interlocking machine) which, because out of order, or by reason of some other abnormal condition, such as an error on the part of a signalman, holds locked a lever which it is desirable to move in order to avoid delaying a train. To prevent hasty action by a disturbed or excited signalman, the release is so made that it can be operated only by turning a screw a certain predetermined number of times. The release must always be restored to its original condition before normal operation of the interlocking machine can be accomplished. See Figs. 2831-2859.

Secondary. That portion of an induction motor or of a transformer which receives power by induction. The term is to be preceded by the same words as in the case of "primary."

Secondary Battery. See **Storage Battery.**

Selective Dispatching or Signal System. A system in which a number of audible or visible signals located along a railway line are connected to a telephone, telegraph or other circuit, and in which any one of such signals may be operated by means of an electric selector without interfering with other signals associated with such circuit. The operation

of the selectors is controlled by the train dispatcher or other official in charge of the system, located at any point along the line. The operation of the selectors does not interfere with simultaneous telephone or telegraph service over the circuit. The use of this system has been principally confined to electric lines. See Figs. 714-739.

Selector. A device whereby the position of one or more functions determines which of several others shall be operated. For example, a single mechanical lever, arranged to clear two different signals, works a pipe line which engages a connection to one or the other of those signals according as a switch is in one or the other of its two positions. This economizes levers. See **Electric Selector.** See Figs. 1021, 1025.

Self-induction. Induction produced in a circuit by the induction of the current on itself at the moment of starting or stopping the current therein.

Semaphore Bearing. The bearing which supports the semaphore casting. See Figs. 3331-3333, 3352-3356, 3378-3395, 3465-3468.

Semaphore Casting. A casting comprising the **Arm Casting** and **Spectacle** of a semaphore signal. See Figs. 3312-3313, 3329-3330, 3370-3377, 3397-3400, 3402-3415, 3423-3427, 3437-3438, 3472-3476.

Semaphore Shaft. The shaft which carries the semaphore casting.

Semaphore Signal. A type of signal introduced on railways in England about 1841 and now in almost universal use for both block and interlocking signals. It consists of an arm about four feet long and ten inches wide, mounted on a post usually twenty-four feet to thirty feet high at one side of the tracks; or on a shorter post supported by a bridge or other structure above the track. Day indications are given by the position of the arm, horizontal, inclined or vertical, and night indications by a light. The pivot of the arm is combined with a spectacle casting holding colored glass disks, which, as the position of the arm is changed, move in front of a lamp mounted on the post. See **Night Signal Indications.** See Figs. 1-33, 229-241, 250-324, 3224-3305, 3319-3327, 3436-3438, 3444-3447.

Semi-automatic Signal. A signal having both manual and track circuit control. Such a signal can be cleared by the signalman only when the track circuit is unoccupied; but it may be put in the "stop" position either manually or by the entrance of a train upon the circuit. See **Electric Slot.** See Figs. 3479-3492.

Separate Pin Leadout Crank. See **Box Crank.** See Figs. 1156-1160.

Series (applied to electric circuits). Two or more pieces of electrical apparatus, such as lamps or motors, are said to be connected in series when all the current from a common source of supply flows from the supply through one piece of apparatus, thence to the next and so on to a return wire leading back to the supply. See **Multiple.**

Series Circuit. A circuit in which the separate sources or separate electro-receptive devices, or both, are so placed that the current produced in it or passed through it passes successively through the entire circuit from the first to the last.

Shackle. See Figs. 1293-1304.

Shell Transformer. A transformer whose primary and secondary coils are laid on each other, and the iron core is then wound through and over them, so as to completely enclose them. A form of iron-clad transformer.

Shim. A thin piece of wood or metal to be put under the rail of a track, on the tie, to compensate for irregularities in surface. In severe and long continued cold weather the ties in a piece of track may become considerably displaced vertically by the action of frost in the ground. It may elevate ties a, b, d, e, g, 1, 2, or more inches, leaving ties c, f in their original positions. Shims must be put on these two ties to give adequate support to the rail.

Short Circuit. A shunt or by-path of negligible or comparatively small resistance, placed around any part of an electric circuit through which so much of the current passes as to virtually cut out the parts of the circuit to which it acts as a shunt. An accidental direct connection between the mains or main terminals of a dynamo or system producing a heavy overload of current. To accidentally produce a short circuit.

Shunt (verb). Literally, to turn aside. To divert a part of an electric current by establishing for it an additional path.

Shunt Circuit. A derived circuit. A branch or additional circuit, provided in any part of a circuit, through which the current branches or divides, part flowing in the original circuit and part through the new branch or shunt. A circuit for diverting or shunting a portion of the current.

Signal. A sign, agreed upon, to convey information. especially at a distance. Specifically, in railway train-operating, a means of conveying information to the person or persons in immediate charge of the movement of a train. See the adjectives **Home, Distant, Disk, etc.** Note.—This book is devoted to fixed signals, as distinguished from hand-motion signals, etc.

Signal Box (British). A **Signal Cabin,** which see.

Signal Bracket. A column or post with offset support (or supports) for signal masts.

Signal Bridge. A bridge, the purpose of which is to support signals above the tracks. The signal post or disk is mounted on the bridge. Used most frequently in yards where there is not sufficient clearance to place a post between tracks. See Figs. 3444-3447.

Signal Cabin. See **Tower.**

Signalman. The attendant at a block or interlocking signal cabin. Often he has the triple function of signalman, switchman and telegraph operator, but with only this one title.

Signal Mast. The upright to which the signals are directly attached.

Signal Mechanism. A term used to denote the apparatus at, or within the case of, or placed upon the post of, a power-operated signal which directly operates the semaphore arm or disk of the signal. See Figs. 512-602, 606, 615, 620, 621, 623, 624, 627, 644, 659, 660, 662, 664, 665, 693-695, 699, 702-703, 705, 706, 709, 711, 732, 733, 1814-1819, 1832-1840, 1885-1888, 1908-1919, 1924-1927, 1946-1951, 1980-1981, 1983-1988, 1995-1997, 2025, 2035-2040.

Signal Post. The upright and supporting member of a semaphore signal. It may be of wood about eight inches square, or of iron, built up, or of iron, tubular (Figs. 1639-1646).

Signal Repeater. An indicator which shows in a tower the changes in position of the arm or movable disk of a fixed signal. See Fig. 2604.

Signal Tower. See **Tower.**

Single Phase. Uniphase. Monophase. Pertaining to ordinary alternating currents in simple alternating current system as distinguished from multiphase currents.

Single-pole Switch. A switch which opens or closes a circuit at one of its leads only.

Single-throw Switch. A switch having but two positions, one for opening, and the other for closing the circuit it controls, as distinguished from a double-throw switch.

Slide Plate. See **Riser Plate.**

Slot. A disconnecting device inserted in the connection between a signal arm and its operating mechanism. See **Electric Slot.** In its original English form the "slot" consists of rods having cut in them long slots. The slot is used to put a signal in the stop position, regardless of the action or inaction of the signalman in charge of such signal. With the slot arrangement a given signal can be put in the stop position by either of two signalmen, but it cannot be put in the clear position except by the co-operation of both signalmen. See Figs. 1734-1735, 3479-3492.

Slotted Signal. A signal in which the connection from the lever or other operating mechanism is controlled by a mechanical or electric slot.

Slow-acting Relay. A relay, the magnets of which are so designed that they retain their magnetism for an appreciable time after the circuit is interrupted, thus delaying the breaking of the circuit controlled by the relay armature.

Slow Board. A sign, usually fixed at the side of a railway, on a board about thirty inches wide and twenty inches high, supported on a post from four feet to six feet high, bearing the word slow, or a legend indicating speed in miles per hour, to warn the enginemen of trains to reduce speed at that point. The rate of speed, if not shown, is governed by explicit instructions which are to be found in the time-table rules, and which are familiar to all of the enginemen running on the line.

Slow Releasing Slot. An electric slot for an automatic signal having a magnet so made as to consume an appreciable interval of time between the breaking of the circuit and releasing. Used instead of and made on the same principles as a **Slow-acting Relay,** which see.

Smash Signal. A signal of special form used at the approach to particularly dangerous points, such as drawbridges. Usually some form of obstruction, such as a long semaphore arm or a large disk, so arranged that when in the stop position, it fouls with the window of the locomotive cab. Where a disk is used it is commonly a plank frame suspended from a bridge over the track, and it is lowered so as to foul with the smoke-stack. If a train runs past the signal while it is in the stop position the "smash" will call the engineman's attention and also will leave a mark on the engine or train. The signal also will be broken, thus affording a double check on the observance of the signal.

Snap Switch. A switch in which the transfer of the contact points from one position to another is accomplished by a quick motion obtained by the operation of a spring.

Soldering Flux. Any chemical suitable for use in connection with solder to cleanse the surfaces of the articles to be soldered.

Sole Plate. See **Insulated Rail Joint.**

Solenoid. A cylindrical coil of wire; a helix. Sometimes used in place of an electromagnet. When so used an iron core is provided which enters the solenoid and is drawn in by magnetic attraction, thus performing the same function as the armature of an electromagnet.

Solenoid Signal. See **Solenoid.** See Figs. 710-712, 1830-1833, 1836-1840.

Space Interval System. The block system, as distinguished from the time interval system of regulating the movement of trains following one another. Time intervals can be maintained only at stations, and trains delayed between stations must be protected by sending a man back along the road with hand signals. As an auxiliary to this protection by flagman, fusees are thrown off from the rear of moving trains. See **Time Interval System.**

Spark Gap. The air-space or gap through which a disruptive discharge passes. A gap forming part of a circuit between two opposing conductors and filled with air or other dielectric, across which a spark passes when a certain difference of potential has been reached.

Spectacle. The casting which holds the colored glass of a semaphore signal. See **Semaphore Casting.**

Speed Control. Control of an automatic train-stopping apparatus by a means which is operative or inoperative, according to whether the speed of the train is or is not above a certain rate. For example, a stopping device may be arranged to become inoperative whenever the train is moving at a rate less than five miles an hour.

Spindle Slot. An **Electro-mechanical Slot,** which see. It is attached to the semaphore shaft of a signal. See Figs. 3488-3492.

Split Link. See Figs. 1293-1304.

Split Phase. A term applied to an a. c. motor, relay or other similar apparatus that depends for its operation on a phase difference in its coils, but is operated by a single-phase current. The phase difference is obtained by "splitting" the phase of the circuit by an impedance coil or other similar device.

Squirrel Cage Armature. A term applied to a special form of rotor of an a. c. motor, consisting of an iron core, within the periphery of which are embedded a number of insulated copper conductors lying parallel to the axis of the core, their ends being united usually by copper rings or disks, so that they form closed circuits.

Staff. That part of the apparatus used in the staff system which is delivered to the engineman as his authority for the use of the block.

Staff Crane. With the electric train staff system, a post with suitable bars to support a staff, fixed near the track to enable the engineman of a train, passing at moderate speed, to reach and take a staff. Staff cranes are also made to receive a staff from a moving engine. With suitable apparatus on the engine staffs may be exchanged at high speed.

Standard Code. The code of rules issued by the American Railway Association. It includes Train Rules, Block Signal Rules and Interlocking Rules. As issued by the Association, each of these three codes contains numerous paragraphs with words or

clauses omitted, the blanks being designed to be filled up, by individual companies, to suit the practice on their respective roads. "Train rules" cover the principal features of the work of the men who operate the trains, including train despatchers and telegraph operators, and also station agents, track foremen and others, so far as their duties have to do directly with the movement of trains. This part of the code was first adopted in 1887, when few American railways had either block signals or interlocking, and many of its rules which under that condition are of vital importance, become secondary or useless when the block system is used. As used by the railways the "train rules" are supplemented by other train rules, usually more voluminous, dealing with the other and less important duties of trainmen.

Standard Interlocking Machine. An interlocking machine having vertical locking arranged in a frame below the surface of the floor. Locking can be arranged in two planes called **Front Locking,** which see, and **Back Locking,** which see. Originally made by The Standard Railroad Signal Company. Sometimes called "Style A" interlocking machine. See Figs. 851-902.

Starting Signal. In Great Britain a common arrangement of signals at block stations is to have three stop signals in succession called, respectively, the home, the starting and the advanced starting signals spaced far enough apart to allow an ordinary train to stand between the first and second and between the second and third. In America the term starting signal has little recognition, officially, but it is used to designate the signals at the outer end of a terminal train shed, or at the outgoing end of a side track.

Static Transformer. See **Transformer.**

Stationary Battery. A complete battery consists of one or more cells performing common work at any given point; the number of cells is determined by the voltage required on working circuit, and the number of plates and size of plates in each cell determined by the capacity in ampere hours required between charges plus factor of safety.

One complete cell consists of positive and negative plates in electrolyte, contained in a glass jar or tank, provided with suitable separators, connectors and covers. A two-plate cell is usually termed a "couple" and consists of a jar containing a positive and a negative plate and electrolyte; each positive plate is burned to the negative plate in the adjacent cell.

The number of positive plates is usually one less than the negatives except in two-plate cells, where one positive and one negative are used. The positive plate is usually brown in color and the negative gray.

All the positive plates in one cell are connected solidly to a lead strap, and this combination of positive plates and straps is technically known as a "positive group."

Similarly the negative plates in one cell are connected together and the combination known as a "negative group."

A cell, therefore, contains a positive group and a negative group assembled with positive and negative plates alternately side by side and separators between plates. This combination of positive and negative groups with separators is known technically as an "element."

One bolt connector is required for each cell, when assembled end to end, with an extra connector for each row of cells. Two-bolt connectors are required for each cell, when assembled side by side, with connecting strap between cells. Two-plate cells or a "couple" require only two connectors for each row, as the positive and negative plates of adjacent cells are burned solidly together. Several two-plate cells, however, are usually set on one tray.

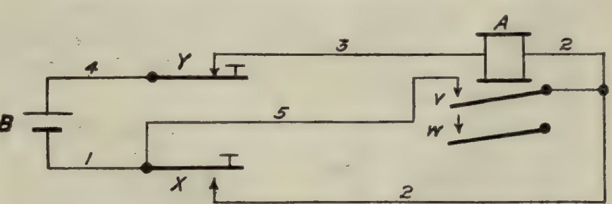
Stator. The stationary member, whether primary or secondary, of any alternating current machine.

Step-down Transformer. A transformer in which a small current of comparatively great difference of potential is converted into a large current of comparatively small difference of potential. An inverted Ruhmkorff induction coil.

Step-up Transformer. A transformer in which a large current of comparatively small difference of potential is converted into a small current of comparatively great difference of potential.

Stevens Interlocking Machine. See Fig. 1006.

Stick Relay. A relay of the ordinary type so connected that its armature closes a circuit through its own coils; that is, there are two paths provided for the current, as shown in the diagram. One path is from battery B through wire 1, key X (when depressed), wire 2, relay coil A, wire 3, key Y, wire 4 and back to battery. This energizes the relay and closes contacts v and w. Contact v being closed current flows from B through wires 1 and 5, con-



tact v, wire 2, and through the coil and back to battery as before. If now key X is opened, the relay will remain energized, current still passing through its armature contact and coil. Thus to one testing the relay by means of key X it seems to "stick;" seems to remain closed by reason of some abnormal cause, after its circuit has been opened. When the key Y is depressed the battery is completely cut off, the relay is de-energized and the "stick" circuit is broken at v.

Stock Rail. In a "split" switch either of the two immovable rails, as distinguished from the movable "point" rails.

Stop (noun). See **Automatic Stop.**

Storage Battery. A collection of storage cells by which electrical energy is transformed into chemical potential energy as a result of electrochemical action, and by which chemical potential energy is transformed into electrical energy as a result of similar electrochemical action in the reverse direction. Theoretically the storage battery is in its original condition at the end of the cycle of operation and is thereby distinguished from a primary or regenerative battery where the element does not work in a continuous cycle, but has to have new material either in whole or in part mechanically supplied to it at the end of the discharge in order to put it in the same condition as at the start. See pages 326-334; Figs. 2243-2296.

Straight Arm Compensator. See **Compensator.** See Figs. 1175-1175, 1177-1178.

Style "A" Interlocking Machine. A term sometimes applied to a Standard interlocking machine, which see.

Suspended Signal. A signal suspended from an overhead signal bridge, or other high structure. See Figs. 3444-3446.

Switch (noun). (1) A pair of movable track rails, with their fastenings and operating rods, providing the means for making a path over which to move an engine, car or train on either of two diverging tracks. (2) A device, in electrical connections, to provide means for closing a path for the flow of current in any one of two or more circuits. Commonly a bar, pivoted at one end, which may be moved so as to touch any one of two or more contacts on as many different conductors.

Switch Adjustment. A device for reducing "overstroke" at a switch. See Figs. 1513-1521. See **Overstroke.**

Switch and Lock Movement. In mechanical interlocking an arrangement of rods and levers by which a single stroke of a lever performs three operations: unlocks the switch, moves it and locks it again. See Figs. 1445-1450, 1484.

Switchboard. A slab of slate or marble on which are mounted the necessary switches, meters and other apparatus required for regulating and controlling the electric current in a power house, sub-station or similar place. The switches and other apparatus are mounted on the front of the switchboard, and the connections and bus bars are mounted on the back. Large switchboards are usually divided into a number of separate panels. See Figs. 2890-2899, etc.

Switch Box. The familiar name for a circuit controller at a switch, which is contained in an iron box. This box is mounted on a long tie about three feet from the nearest rail of the track and is connected to the point of the switch by a rod. The opening of the switch makes or breaks an electrical contact in the box. See Figs. 2416-2462.

Switch Circuit Controller. See **Switch Box; Electric Selector.**

Switch Indicator. A device to indicate visually or audibly, or both, to the person moving an isolated switch, whether or not a train has entered or is approaching the block in which the switch is situated, and if it is permissible to open the switch. Used principally in connection with automatic block signals. The visual indicator consists of a pair of magnets and an armature, to which is attached a small movable disk or miniature semaphore arm. The whole apparatus is enclosed in a weatherproof case, having a glass front, which is mounted on a post near the switch stand. The magnet coils are energized by a line wire circuit which extends back at least two full block sections, and which passes through normally closed contacts on all the intervening track relays or through normally closed contacts on the home signal arms. When this circuit is broken by the presence of a train anywhere within the limits of the circuit, which would open one or more contacts, the armature drops and moves the disk or semaphore arm into the position, indicating the approach of a train and giving warning against opening the switch. The audible warning is given by a vibrating bell connected through a similar circuit. The bell, however, is usually arranged to ring only when a train is approaching the block and is cut out as the train enters the block. The line-wire circuit for both the audible and the visual indicator is carried back far enough, so that warning of the approach of a train will be given at the switch before the train comes in sight of the distant signal controlled by the first home signal in the rear of the switch. See Figs. 2630-2674.

Switch Instrument. See **Switch Box** and **Electric Selector.**

Switch Lock, Electric. See **Electric Switch Lock.**

Switch Rod. See **Switch.**

Switch Tender. A person who tends switches. Applied to attendants of ground switches, which usually are not interlocked. The attendant in an interlocking tower moves and controls switches, as well as signals, but his designation is signalman.

Sykes' Lock and Block Instrument. The controlled manual block signal apparatus invented by W. R. Sykes in England, and the first used in America. A few Sykes' instruments were installed on the New York Central as early as 1882, but these have since been replaced by later designs. The Coleman machine embodies all of the features of the Sykes machine and a number of additional safeguards. The Sykes system, as used on the New York Central, was applicable only to double-track roads, since the release is accomplished while a train is passing over a short releasing track circuit, which in the case of a single-track road would release the machine ahead of the train as well as in the rear and might result in allowing two trains moving in opposite directions to enter the block at opposite ends at the same time. See **Controlled Manual Block System.**

Synchronism. A simultaneous occurrence of any two events. An a. c. motor is said to be synchronous when its rotor revolves at the same speed as the rotor of the generator. A synchronism motor is said to be in step with the generator.

Synchronous Motor. See **Synchronism.**

T

Table Lever. A lever for working a block signal very near the office, fixed in the telegraph operator's table.

Tail Lever. The arm of the lever of an interlocking machine, to which the operating pipe or wire is connected. See **Interlocking Machine.**

Tang End. A projection on the end of a jaw or rod one-half the length of a pipe plug, used to stiffen the joint between the pipe line and the jaw or rod in the same manner as the pipe plug, which see. See Figs. 1026-1121.

Tappet. (1) (In an interlocking machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them. (2) (In an interlocking machine with horizontal locking.) A pivot or swing dog attached to the locking bar and actuated or locked by the cross-locking. See **Interlocking Machine.**

Tappet Circuit Controller. The circuit controller operated by the movement of the lever latch handle, and usually by movement of the tappet.

Telegraph. See **Telegraph Block System, Manual Block System, Controlled Manual Block System, Needle Telegraph, Morse Telegraph.**

Telegraph Block System. "A series of consecutive blocks controlled by block signals operated manually upon information by telegraph" (A. R. A.). Another name for the **Manual Block System,** which see. The American Railway Association has adopted this term (as above), although it is not strictly confined to a system in which the telegraph is the means of communication between block stations, bells or telephones being used in some cases.

Telephone. Apparatus by which sounds (of the human voice) are repeated at a distance. Used as a means of communication. See **Manual Block System; Controlled Manual Block System; Telegraph Block System.** See Fig. 3551.

Telephone Train Dispatching. See **Selective Dispatching or Signal System.**

Terminal Board. A collection of binding posts mounted on a slab or board to which the ends of a number of wires may be attached and interconnected, as desired, by short pieces of wire or metal strips called jumpers.

Thomas Interlocking. A system of pneumatic interlocking using compressed air only at a pressure of 80 lbs. per square inch. It depends for its operation on a difference of pressure of 10 lbs. between the pipes, both in working a function and obtaining the indication. This system was invented by J. W. Thomas, Jr., and orginally installed at Nashville on the Nashville, Chattanooga & St. Louis.

Threaded Rod. A term sometimes applied to a **Throw Rod,** which see.

Three-phase Currents. Three alternating currents differing in phase from one another by one-third of a cycle.

Three-position Automatic Block Signals. A system of automatic block signals designed to provide the protection of distant signals without the duplication of signal arms usually involved. Each signal arm is so arranged that it may be put in any one of three positions; horizontal for stop; inclined 45 deg. for "caution" and vertical for proceed. The signal goes to the stop position when a train enters the block; when the train has cleared the block it moves to the caution position, and it remains in that position until the next signal in advance moves to the caution position, when it goes to "clear." A train is thus always protected by a stop signal in the rear and a caution signal one block further back. Three-position automatic block signals were first introduced on the Pennsylvania Lines West of Pittsburgh in the year 1900.

Three-position Signal. A semaphore signal arranged to give three different indications. See Figs. 136-141, 165-176. In a common form (manually operated) the horizontal position of the arm indicates "stop," the arm inclined downward 37½ deg. "caution" (permissive block signaling) and inclined downward about 75 deg. "proceed" (speed not limited). On a few roads the arrangement is horizontal "stop;" upward 45 deg., "caution;" downward, 45 deg., "proceed" (speed not limited). In automatic three-position signals (which see) and in some manual signals the proceed position is vertical (90 deg. from horizontal), but the arm is made to stand clear of the post, so that the engineman may see that it is not missing.

Throw Rod. The rod connecting a switch to its operating mechanism. The throw rod is connected to the head rod of the switch by a switch adjustment, which see. See also Figs. 1513-1521.

Tie Plate. In interlocking work, an iron plate fastened to the upper surface of a tie or sleeper and extending across the track beneath the rails. Used principally at switches and movable point frogs in connection with rail braces, butt straps and slide plates, to hold the track to gage.

Tie Strap. A flat iron rod or bar, fastened by spikes or lag screws to the ties (as at a switch) to hold the ties in position.

Tie Wire. A short piece of wire used to tie line wires to insulators. See Figs. 3005-3006.

Time-Interval System. The rules under which trains are run where there is no block system. To obviate the danger of rear collisions in consequence of unexpected delays to trains between stations the attendant at each station sees that a prescribed interval, usually five, seven or ten minutes, is maintained between trains. This interval is intended to allow time enough for the protection of a delayed train by sending back a flagman to warn any following train. At night the flagman carries a red lantern. Both night and day he carries torpedoes with which to give audible signals, and fusees, which see.

Time Lock. A device similar in purpose to a time release. It is usually automatic in action. See **Time Release.** See Figs. 2831-2859.

Time Release. A device for releasing an electric lock (on a signal or other lever) when it remains locked because of abnormal conditions and thereby delays traffic. See **Screw Release.** See Figs. 2831-2859.

Time-Table. The statement of stations, trains and times, issued by the superintendent of a railway for the guidance of the men in charge of trains. It is the authority for the movement of regular trains. A schedule—one column in a time-table—prescribes the class, direction, number and movement of a regular train, showing where and when it begins its trip and the time at each station. On a single-track railway the rules regulating meeting points are a vital element of the time-table; but where the block system is used these and many other time-table rules become of minor importance, as provisions for safety, though they still remain important as matters of convenience. Time-tables contain local or temporary rules modifying the general train rules contained in the Standard Code of Rules.

Tommy Bar. See Fig. 3559.

Torpedo. An explosive cap, the size of a small watch, to be fastened on the top of a rail of the track, to be exploded by the pressure of the first wheel of an approaching engine or train. The detonation indicates "stop." Torpedoes are used when, by reason of fog, snow or darkness, a visible stop signal may not be seen by the engineman. See Figs. 3511-3512.

Torpedo Placer. An apparatus for putting torpedoes in position to be exploded by the passage of a wheel of a locomotive or other vehicle. In the design shown in Figs. 3513-3514 the torpedo lies beneath an anvil which is at the side of the rail and is depressed by the outer part of the tread of a wheel. On British railways where torpedoes are usually placed by hand by attendants (in times of fog) a hand placing-apparatus is sometimes used, to

relieve the attendant from the dangerous duty of crossing tracks, as is necessary in the case of a four-track line.

Torque. The moment of a force causing rotation; the product of the force and the distance from the point of application of the force to the center of rotation. The mechanical rotary or turning force which acts on the armature of a generator, motor or other machine and causes it to rotate. In the case of the rotor of a generator or motor the torque is equal to the radius of the armature multiplied by the pull at the circumference, or the radius of its pulley multiplied by the pull at the circumference of the pulley. A torque is exerted on the shaft of a motor from the electro-magnetic action or pull at the periphery of the armature. The torque is usually measured in pounds of pull at the end of a radius or arm 1 ft. in length.

To the Rear of a Signal. The section of track occupied by a train before it has passed a signal.

Toucey & Buchanan Interlocking. One of the earliest American interlocking machines. Used on the New York Central; now superseded.

Tower. A common name for the building from which signals are operated. Usually two stories high, with the signalman's room in the second story; sometimes called a cabin. Some interlocking towers containing machines of many levers, are from 50 ft. to 100 ft. long. See Figs. 3884-3908.

Track Bond. See **Rail Bond.**

Track Circuit. An electric current flowing through the rails of a railway track. In a typical track circuit, Fig. 326, the current flows from the battery to the nearest rail of the track, thence to the other end of the track circuit section; thence by wire to the track relay (controlling a signal) back by a wire to the farther rail, and by that rail back to the battery. Each rail is made electrically continuous from one end of the track-circuit section to the other by metallic bonds at the joints, and at the ends of the section insulated joints are used. See **Rail Bond; Insulated Rail Joint.** See Figs. 406-483.

Track Circuit Locking. Electric Locking, which see, accomplished by track circuits.

Track Indicator. A map-like reproduction of railway tracks, made on transparent glass, controlled by track circuits so arranged beneath the glass as to indicate automatically, for defined sections of track, by distinctive colors, whether or not such sections are occupied by a vehicle or vehicles. Used principally at interlocking plants. See **Indicators,** Figs. 2550-2674.

Track Instrument. A lever fixed to a tie, to be moved by the weight of the wheel of a passing train, or by deflection of a rail under the weight of the wheels, and designed to open or close an electric contact in an electric circuit. Used to control circuits for highway crossing bells, annunciators, etc. In automatic block signaling without track circuits (formerly in use in New England) two such instruments are required for each signal, one at the entrance to the block, in which the contact is normally closed and is opened, by the passage of a train, to move the signal to the stop position, and the other, at the outgoing end of the block, in which the contact is normally open and is closed, by the passage of the train, to restore the signal to the clear position. The two instruments are connected with the signal mechanism by wire strung on poles. Wire-circuit signals were used as early as 1871, but are now obsolete, having been generally superseded by **Track Circuit Signals.** See Figs. 2232-2242, 2487-2488.

Track Model. In an interlocking machine, a map-like miniature reproduction (with movable pieces representing the switches) of the tracks in which are the switches controlled by the machine. See Figs. 2615, 2625-2628. Following each movement of a switch, the attendant, who has moved the lever, sees the effect of his action repeated on the model.

Track Relay. A relay in a track circuit. See **Relay.**

Traffic Lever. A **Check Lock Lever,** which see.

Traffic, Maximum, on a Block Signal Line. See **Block Signaling for Maximum Traffic.**

Trailing Point Switch. The opposite of **Facing Point Switch,** which see.

Train Describer. An electrical instrument designed to give information regarding the origin, destination, class or character of trains, engines or cars moving or to be moved between defined points. Used in signal towers to announce trains from one tower to another, or from train sheds to towers or dispatchers' office. See Figs. 2605-2606.

Train Dispatcher. The officer who supervises the movement of the trains on a given division of railway, sending telegraphic orders to the conductors and enginemen of trains for which the time-table does not give full authority. On a single-track line he must by this means adjust the relative rights of opposing regular trains when one or both is behind time and those of all extra trains.

Train Order Signal. A fixed signal—semaphore or other—used at a telephone or telegraph station to indicate to a train that it must stop there to receive a telephone or telegraphic order affecting its right to the road. Such a signal is usually manually operated by the telephone or telegraph operator in charge of the station. In the selective telephone or telegraph train dispatching system, however, it is controlled by a selector operated over the telephone or telegraph circuit by the dispatcher from a distant point. It is equipped with an answer-back mechanism which indicates over the circuit to the dispatcher that the board or signal is set to stop position. The board cannot then be set to the clear position without the consent and co-operation of the dispatcher. See Figs. 3319-3327.

Train Sheet. The sheet—usually a single sheet for each day of twenty-four hours—on which a train dispatcher records the passage of all the trains that run over his division or district on that day. When filled up it resembles a time-table, with the addition of names of trainmen, numbers of engines, etc. The train sheet at a block-signal station, sometimes called a block sheet, is used to record the times of the trains usually at three stations only; the station where the record is made, the one before it, and the one after it.

Train Staff. See **Staff System; Electric Train Staff System.**

Train Stop. See **Automatic Stop.** See Figs. 3691-3700.

Transformer. A device for transforming an alternating current of high voltage into an alternating current

of the same frequency, but of lower voltage, and greater amperage or vice versa. A transformer which reduces the voltage is a step-down transformer; one which increases the voltage is a step-up transformer. The usual form consists of two separate coils of wire wound on a soft iron core. The coil carrying the impressed current is the primary and the other is the secondary. The action in the transformer is entirely inductive, the current flowing in the primary coil inducing magnetic lines of force in the core, which in turn induce a current in the secondary coil. The voltage in the primary and secondary coils vary approximately with the number of turns of wire in each and the current inversely as the number of turns. Thus, with 500 turns in the primary and 100 turns in the secondary the reduction in voltage would be 5 to 1 and the increase in current would be as 1 to 5. See Figs. 2970-2977.

Transverse Pipe Carrier. A pipe carrier designed to guide pipe across tracks; usually supported on ties; sometimes called a hanging pipe carrier. See **Pipe Carrier.** See G, H, K, L, N, Figs. 1205-1233, and Figs. 1242-1254.

Trick. A tour or turn of duty. The "third trick" in a telegraph or block signal station usually means the tour of duty from midnight to 8 a. m.

Trip. In automatic train-stopping apparatus, the bar, lever, or other device, fixed on or near the track or roadway, which when in a certain position, trips or releases the apparatus on the vehicle, by which release the setting of the brakes is effected.

Triple-pole Switch. A switch consisting of a combination of three separate switches for opening or closing three circuits at the same instant. A switch employed to open or close three contacts. A switch employed to open or close triphase circuits.

Trunking. The wooden casing used to protect from snow and from mechanical injury wires, both electrical conductors and those used to pull signal arms when they lie on or near the surface of the ground. See Figs. **3701-3883.**

Trunnion. A cylindrical projection on a revolving part for supporting it in a bearing.

Tunnel Signal. A signal designed to be placed in a tunnel. It gives indications usually wholly by colored lights. Sometimes called a light signal. A **Pot Signal,** which see, is sometimes used as a tunnel signal.

Two-Light Signal Aspects (system of). An arrangement of semaphore signals, in which every signal shows, at night, at least two lights, as, for example, at a signal where there is a main route and one diverging route. At a block signal where no diverging route is to be signaled the second or lower light (never indicating proceed) is of use to assist the engineman in quickly reading the upper one. A second arm may be used as well as a second light, so as to give the desired aspect in daylight as well as at night.

U

Unit, Interlocking. See **Operated Unit.**

Up-and-Down Rod. The common name for the movable vertical rod connecting a semaphore signal arm with the operating mechanism at the base of the signal post.

Upper Quadrant. One of the quarters of a circle above its horizontal axis; a term used of semaphore signals, in which the arm, normally horizontal (indicating stop) is turned upward to give other than stop indications.

V

Vane Relay. A type of alternating current relay in which a light metal disk, or vane, perforated with radial slots, is caused to move between the pole pieces of magnets to close contacts when the magnets are energized, or open them through the falling of the vane by gravity, when the magnets are de-energized. See Figs. 680-684.

Variable Resistance. A resistance, the value of which can be readily varied or changed. An adjustable resistance.

Vault. Receptacle for housing batteries in the ground below frost line. See **Well.**

Vertical Locking. Mechanical locking arranged in a vertical plane. See **"Standard," National and Johnson Interlocking Machines.**

Volt. The practical unit of measurement of electromotive force. Such an electro-motive force as will cause a current of one ampere to flow through a circuit with a resistance of one ohm. See **Ampere.**

Voltmeter. An instrument for measuring, in terms of volts, the electro-motive force of a current of electricity. It is similar in principle and construction to the **Ammeter,** which see, but the coil is wound with many turns of fine wire so as to work with very small currents and a resistance of several thousand ohms is usually placed in series with it. See Testing Instruments, pages 484-489; Figs. 3515-3558.

W

Watt. The unit of electric power. The product of volts times amperes. One horse-power is equal to 746 watts.

Watt Hour. The unit of electric work, representing the expenditure of one watt for one hour.

Watt Meter. An instrument for measuring the power of an electric current passing through any circuit It is provided with two sets of coils. One is a current coil and the other, suspended inside the first, is free to turn. This measures the voltage of the current passing. The torque produced, tending to displace the revolving coil, is proportional to the product of the magnetic fields developed by the fixed and the movable coil and therefore is proportional to the energy or electrical power passing in the circuit. The amount of the displacement is read by a pointer on a graduated scale.

The more usual form is the integrating watt meter, which records on a series of dials, the number of watt hours of power consumed. The Thompson integrating watt meter, which is the best-known type, is essentially a small motor, the speed of which is proportional to the power in the circuit. The entire current flows through the field coils, which are wound with heavy wire. The armature, which is wound with very fine wire, is in series with a very large resistance placed across the mains. The armature shaft carries a copper disk, revolving between the poles of three drag magnets, which produce a constant retarding force.

The other end of the armature shaft carries a worm to drive the recording gear. Such a meter will register within 2 per cent for long periods without adjustment.

Well. A large concrete or masonry receptacle for batteries to house them in the ground below the frost line. Commonly made complete and sunk to place. See **Battery Chute.** See Figs. 2400-2409.

Wheel. See **Chain Wheel.**

Wide Jaw. See Figs. 1026-1121.

Wire (Electric Conductors). For telegraph lines galvanized iron wire of size 8 or 9, B. W. G., is in extensive use. Copper wire of size 10, 12 or 14, B. & S., is also much used. Line wires used in automatic block signaling are of size 10, 12 or 14, B. & S., but a "common wire" serving as the return portion of a number of circuits is usually larger. All of these are sometimes covered with a continuous insulating covering. Wires inside of buildings and those connecting instruments and lines to the rails of the track are of copper, insulated. See **Cable, Copper-Clad Wire, Insulated Wire.** See Figs. 3909-3924.

Wire Carrier. A roller or pulley supported in a frame, used as a support and guide for a wire line. See Figs. 1309-1335.

Wire Compensator. In a mechanical interlocking plant, a device for automatically keeping the length of a wire uniform under variations in temperature. See **Compensator.** See Figs. 1409-1410.

Wire, Conductivity. See Table on page 514.

Wire Eye. See Figs. 1305-1306.

Wire Gage. See Table on page 514.

Wire Run. In an interlocking plant, an assemblage of wire lines, with their carriers and foundations, in a common course.

Wire, Signal. In manually operated semaphore signals, the wire, usually of steel, about No. 8 or No. 9, B. W. G., connecting a signal arm with its lever in the cabin. It is supported on wire carriers fixed to short stakes set in the ground; or, if such are conveniently situated, on the heavier foundations used to support pipe connections. In either case the wire may be covered with trunking, which see. The wire by which a signal is pulled to the clear position is called the front wire; that used to pull it to the stop position is the back wire. This last is sometimes omitted. In Europe it is generally omitted as the counterweight, close to the signal arm, is depended on to pull the arm to the stop position when the front wire is slackened. In case of breakage of the front wire, the counterweight is designed to pull the arm to the stop position. Where a signal wire line must be sharply turned to one side, a piece is cut out and a chain inserted in place of the wire, and the chain runs around a grooved wheel. In consequence of the difficulty of adjusting signal wires, when they are lengthened or shortened by changes in temperature, rods (pipe) are now generally used, except for signals, very far from the cabin. For these signals at a distance the wire must be adjusted when necessary by screws in the tower; or an automatic wire compensator is used. To avoid the difficulties connected with long-distance signal connections many companies use, to operate distant signals, electric motors (fixed at the signal), such as are used for automatic block signals. These are controlled by an electrical connection from the tower.

Wires, Sizes of. The diameters and weights of the different sizes of wire, according to the Birmingham and the Brown & Sharpe wire gages, with other information are given in the tables on page 514, etc.

"Wireless" Automatic Block System. A term used to define that arrangement of automatic block signals in which line wires for the control of distant signals are dispensed with. The home signal controls the clearing of the distant signal by changing the polarity of the track circuit which extends from the home back to its distant. When the polarity is changed there is a brief period of time during which no current flows. To prevent this from opening the signal circuit and wrongfully putting the home signal in the stop position a "slow-acting" relay or slow releasing slot is used; before the armature falls the current is restored.

Wood Filler. See **Insulated Rail Joint.**

Z

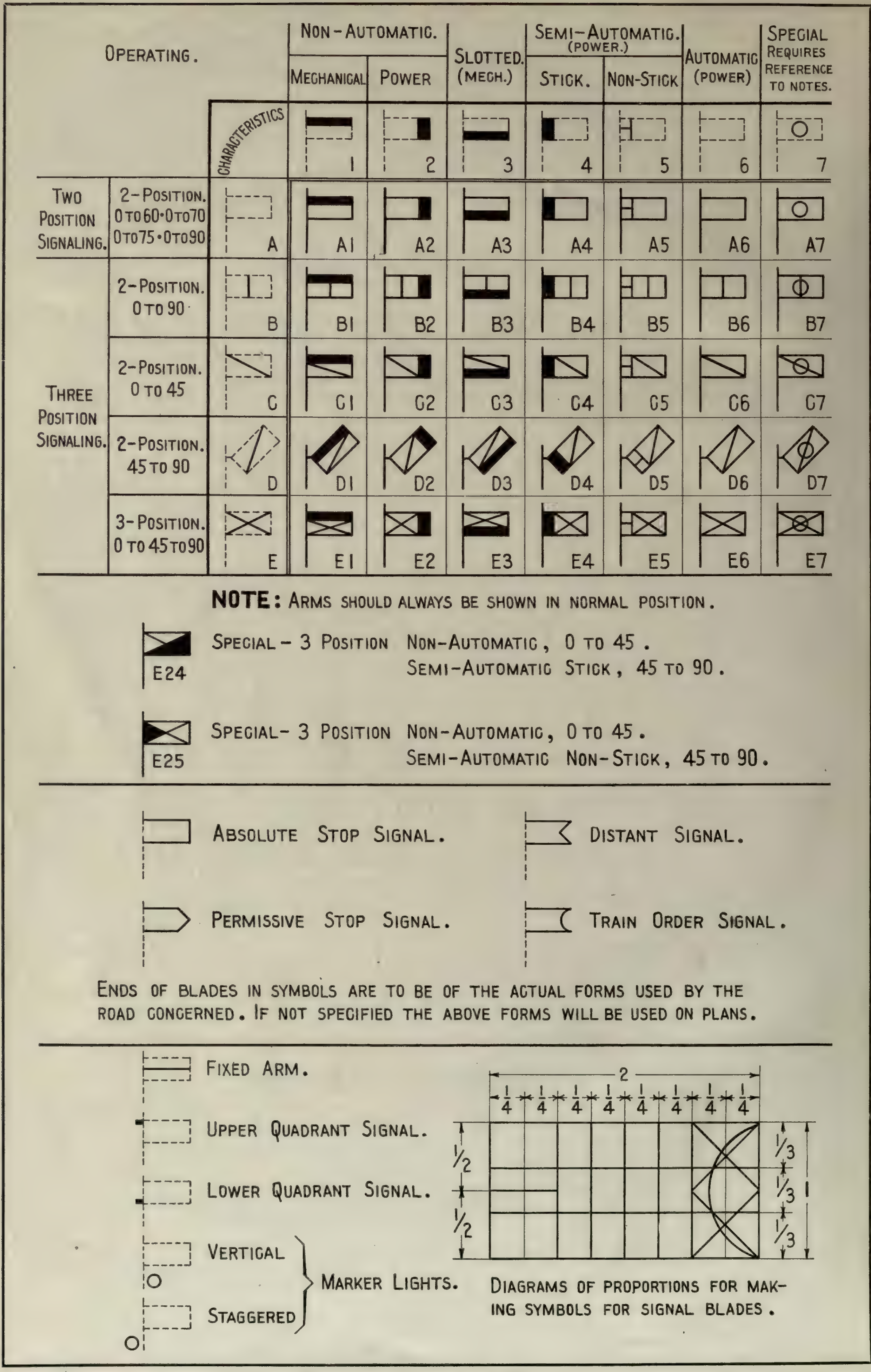
Z Armature. An armature (of an electro-magnet) shaped like the letter Z; used in enclosed disk signals, switch indicators, etc. See Figs. 513-520.

STANDARD SYMBOLS

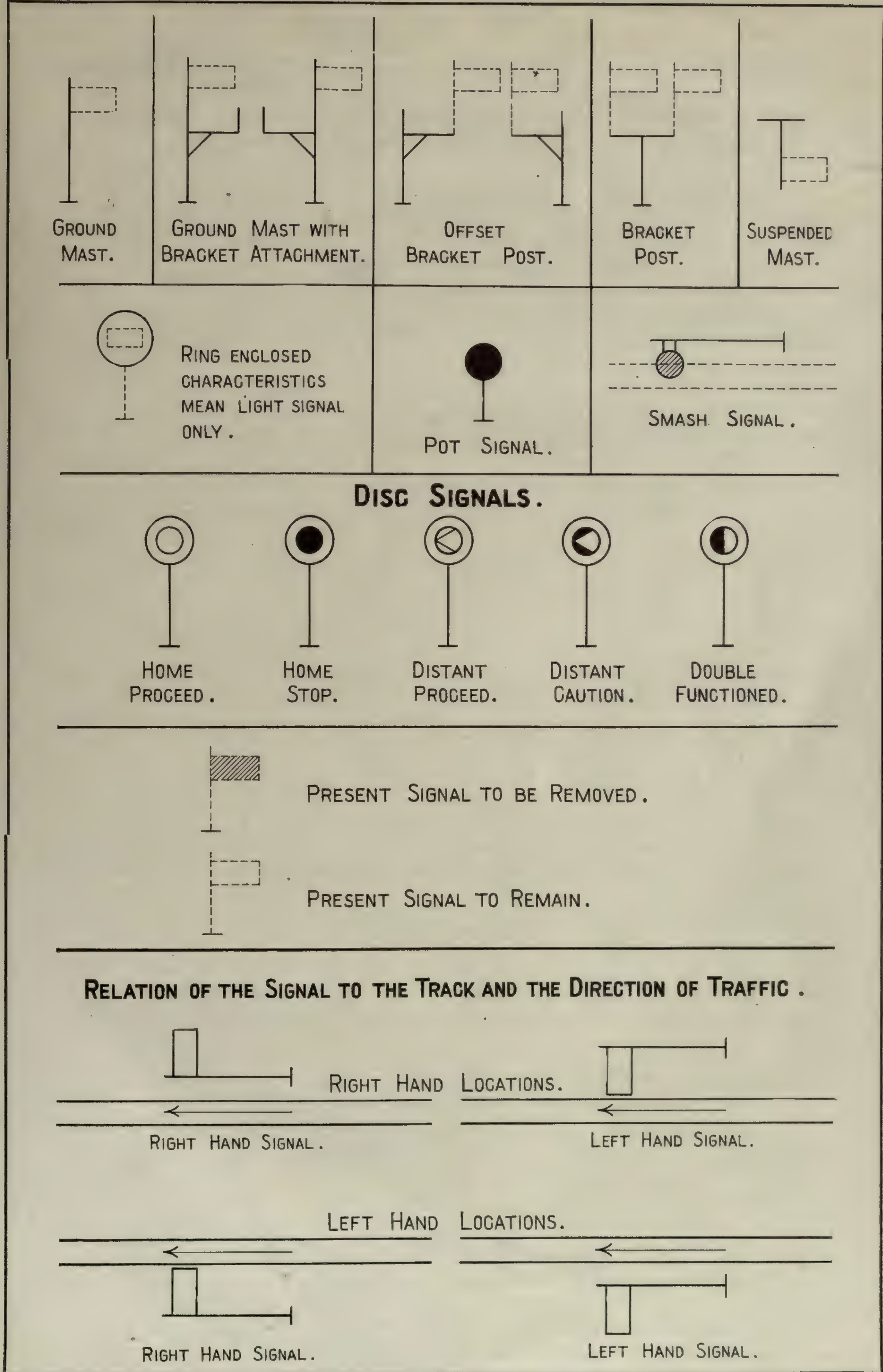
Pages 2-13 Figures 1-224

SIGNAL INDICATIONS

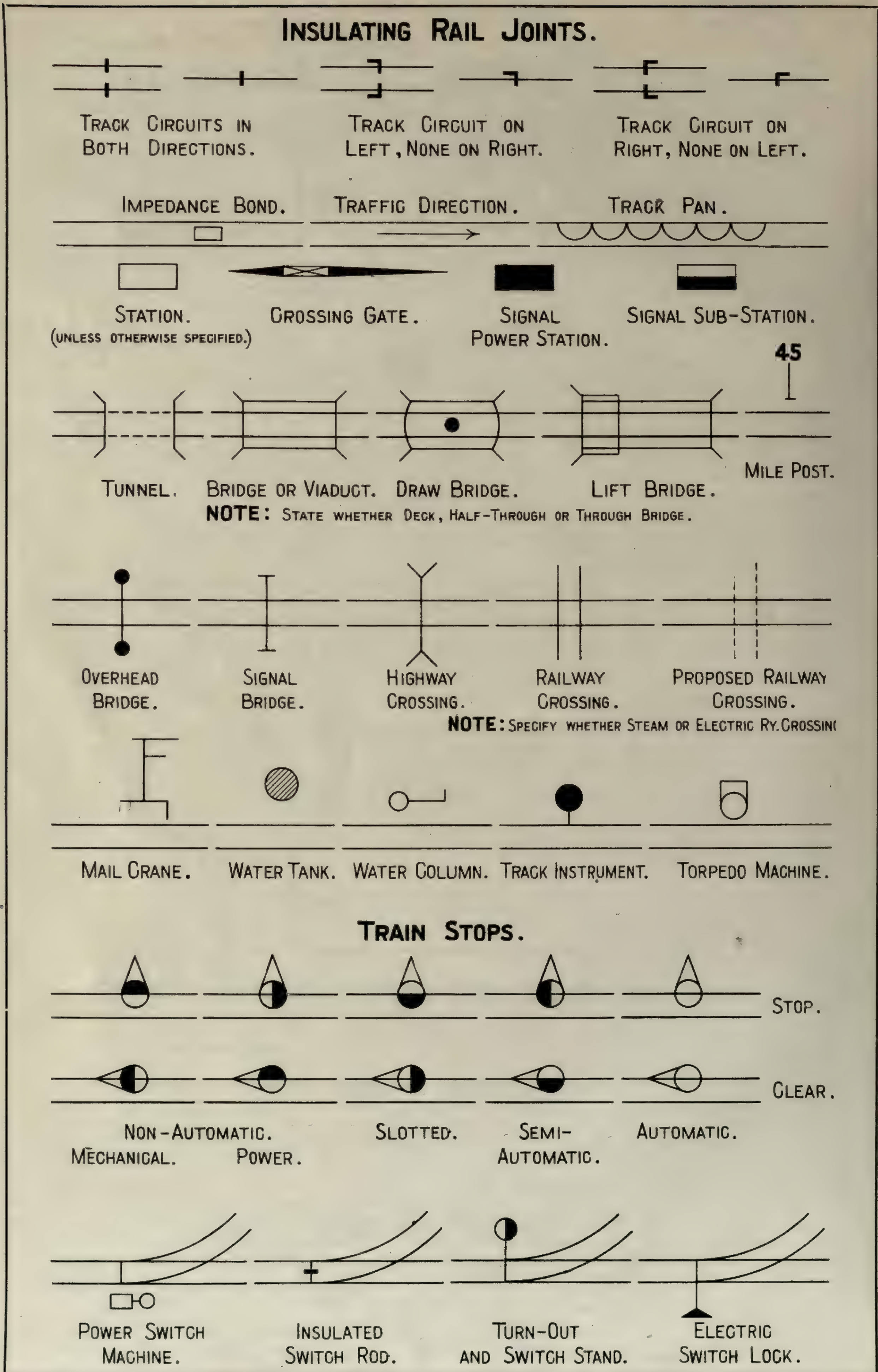
Pages 14-20 Figures 225-307



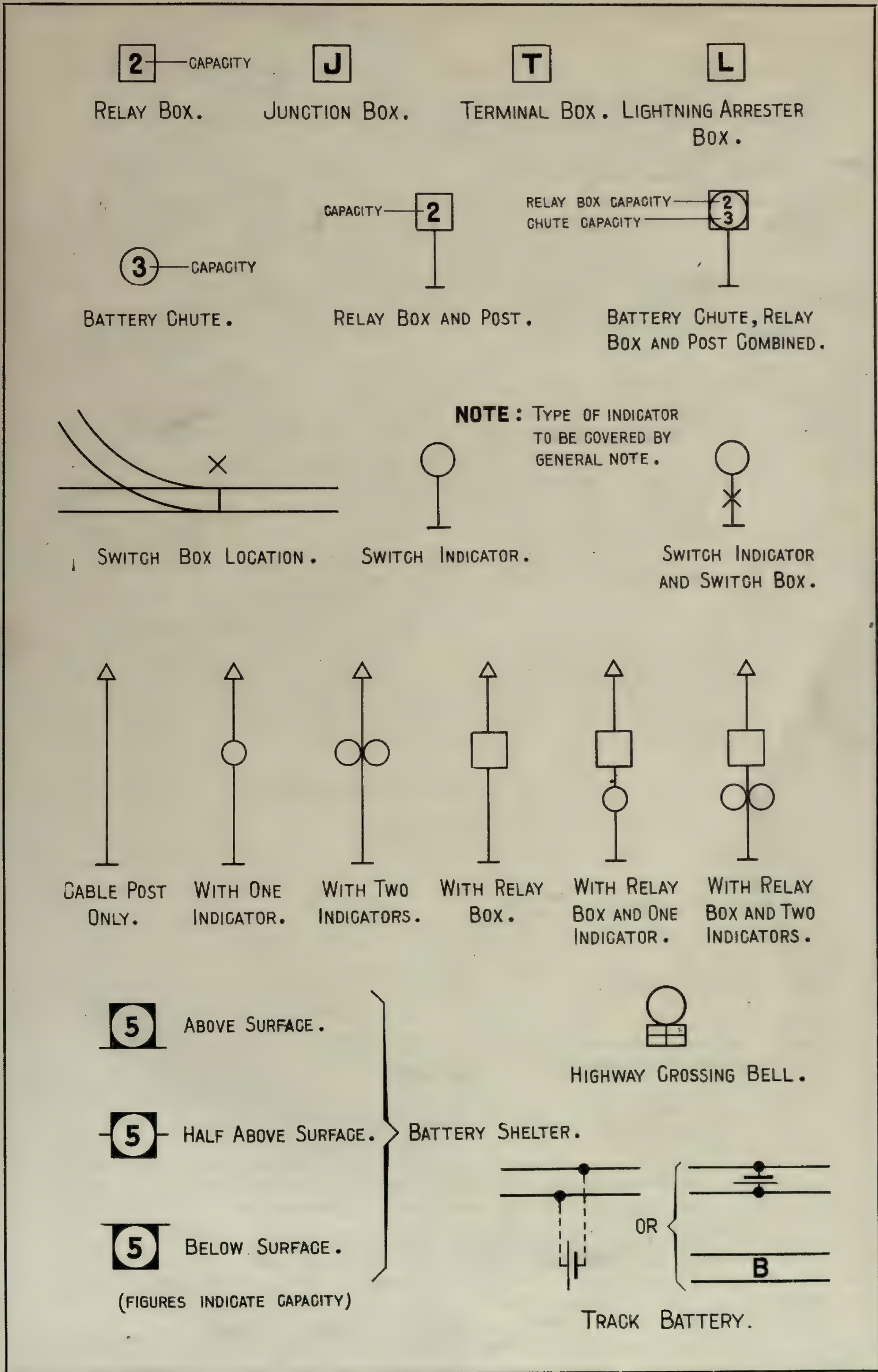
Figs. 1-13. Symbols for Signals.



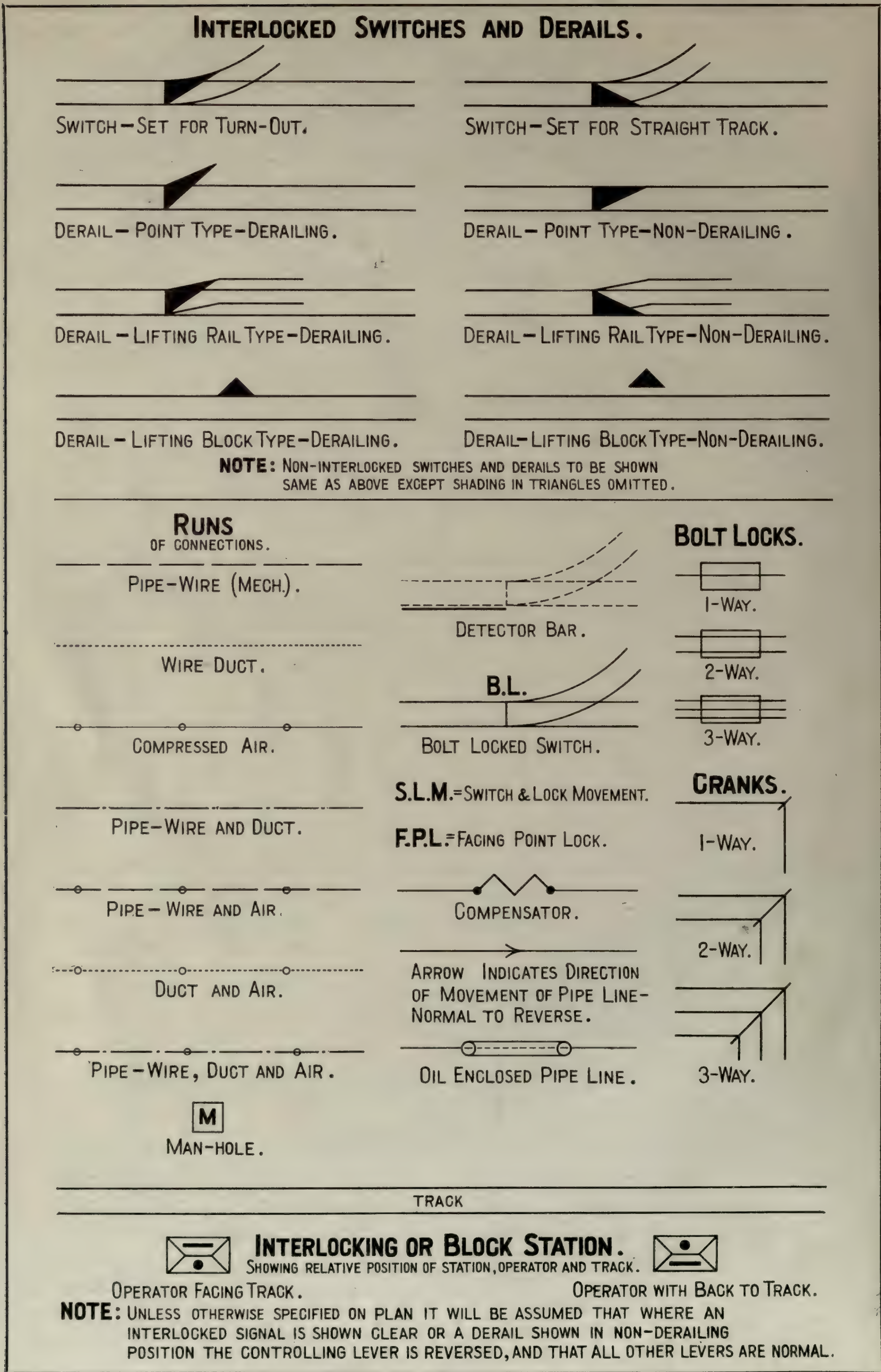
Figs. 14-33. Symbols for Signals (continued).



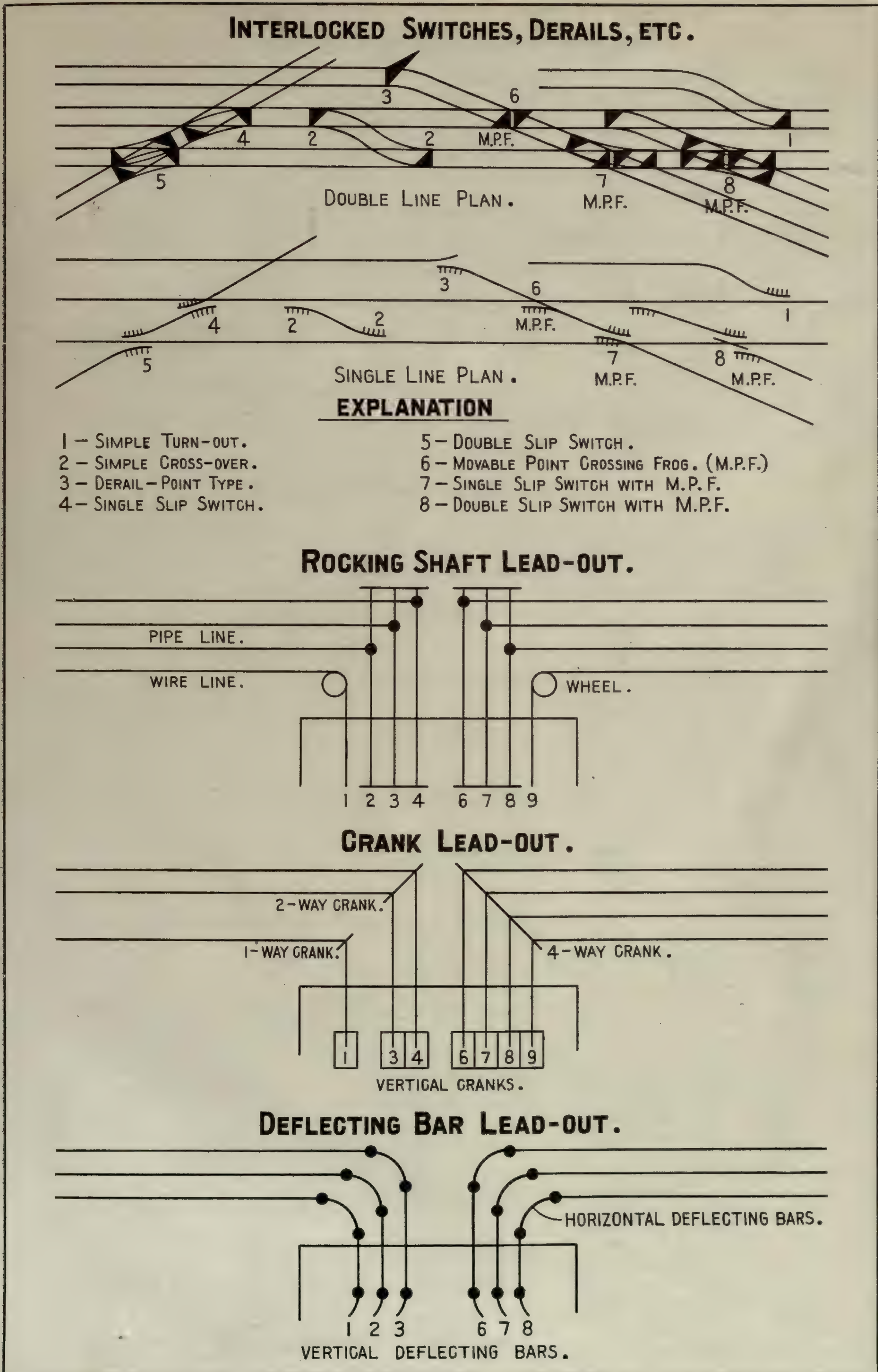
Figs. 34-76. Location Symbols.



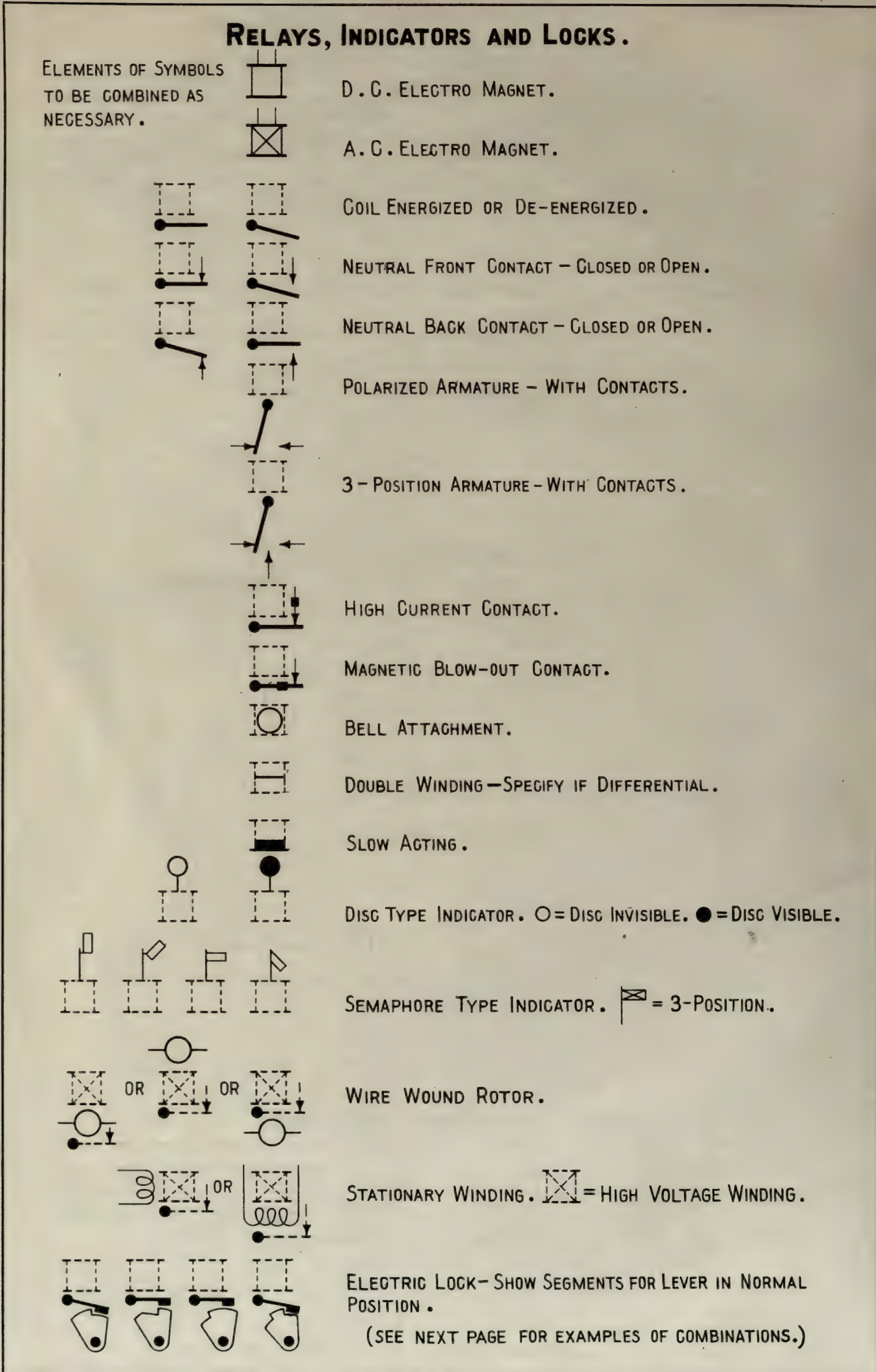
Figs. 77-100. Location Symbols (continued).



Figs. 101-133. Location Symbols (continued).



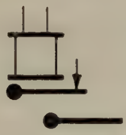
Figs. 134-138. Location Symbols (continued).



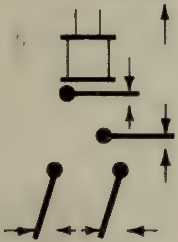
Figs. 139-157. Symbols for Circuit Plans.

RELAYS, INDICATORS AND LOCKS.

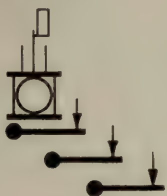
EXAMPLES OF COMBINATIONS.



D.C. RELAY – NEUTRAL – ENERGIZED –
ONE INDEPENDENT FRONT CONTACT CLOSED –
ONE INDEPENDENT BACK CONTACT OPEN.



D.C. RELAY – POLARIZED – ENERGIZED –
TWO COMBINATION FRONT AND BACK NEUTRAL CONTACTS –
TWO POLARIZED CONTACTS CLOSED –
TWO POLARIZED CONTACTS OPEN.

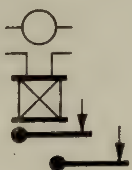


D.C. INDICATOR – SEMAPHORE TYPE – ENERGIZED –
THREE FRONT CONTACTS CLOSED –
BELL ATTACHMENT.

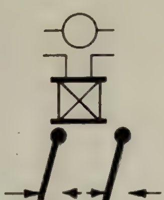
D.C. INDICATOR – SEMAPHORE TYPE – ARM HORIZONTAL –
ENERGIZED – WITHOUT CONTACTS.

NOTE: INDICATORS (OR REPEATERS) WITHOUT CONTACTS SHOULD BE SHOWN WITH ARMATURES TO INDICATE WHETHER ENERGIZED OR DE-ENERGIZED.

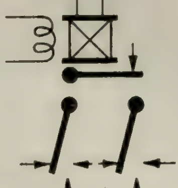
A.C. RELAY – ONE ENERGIZING CIRCUIT TYPE (SINGLE PHASE)
ENERGIZED – ONE FRONT CONTACT.



A.C. RELAY – TWO ENERGIZING CIRCUIT TYPE – ENERGIZED –
WIRE WOUND ROTOR –
TWO NEUTRAL FRONT CONTACTS.



A.C. RELAY – TWO ENERGIZING CIRCUIT TYPE – ENERGIZED –
WIRE WOUND ROTOR –
TWO POLARIZED CONTACTS.



A.C RELAY – TWO ENERGIZING CIRCUIT TYPE – ENERGIZED –
STATIONARY WINDINGS –
ONE NEUTRAL FRONT CONTACT –
TWO 3-POSITION CONTACTS.

D.C. INTERLOCKED RELAY.

D.C. ELECTRIC BELL.

DESIGNATE RESISTANCE IN OHMS OF ALL D.C. RELAYS, INDICATORS AND LOCKS.

Figs. 158-168. Symbols for Circuit Plans (continued).

Circuit Controllers Operated by Levers.

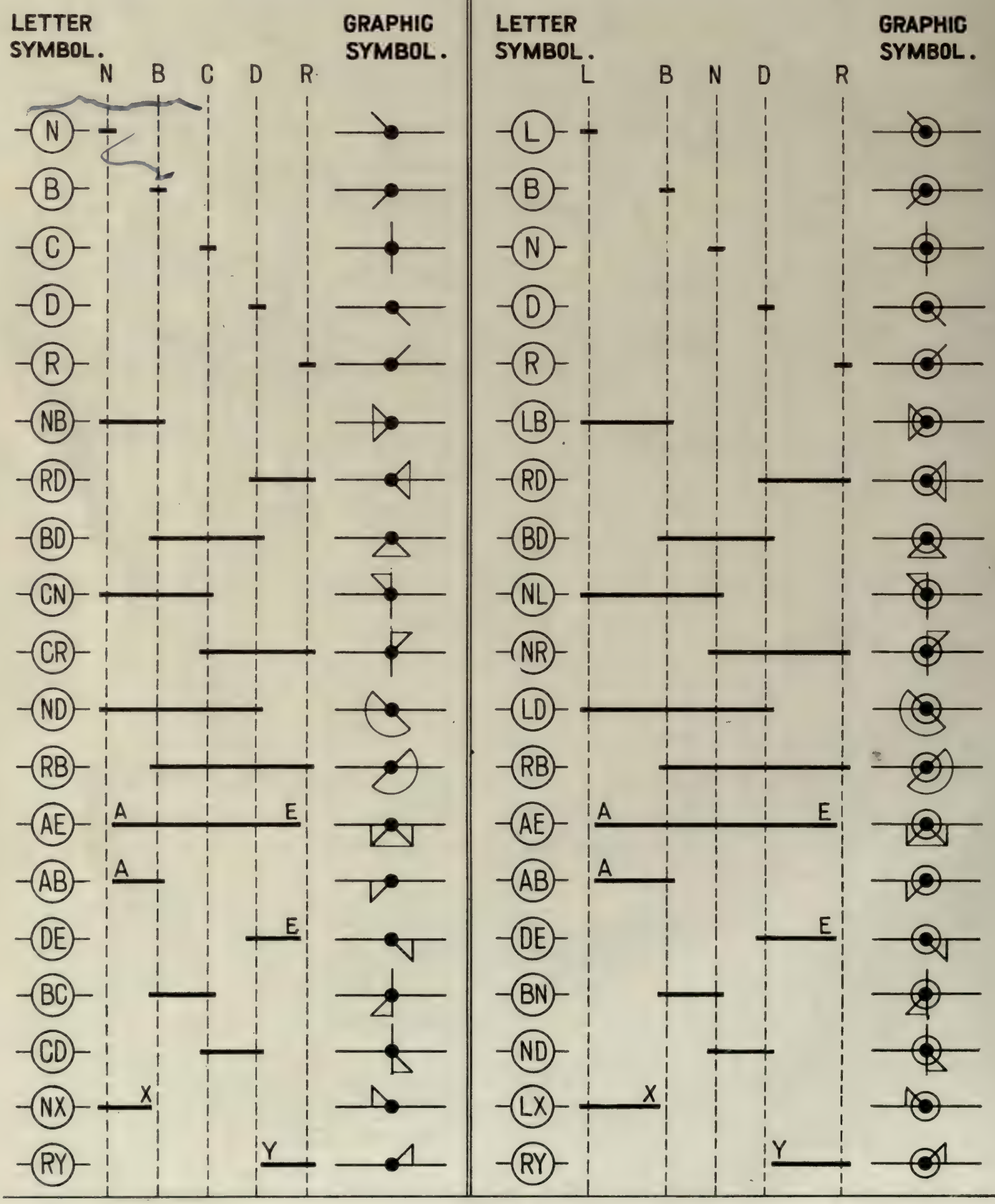
Use either Letter System or Graphic System.

Levers with Extreme End Position as Normal.

N-Full Normal Position of Lever.
B-Normal Indication Position.
C-Central Position.
D-Reverse Indication Position.
R-Full Reverse Position.

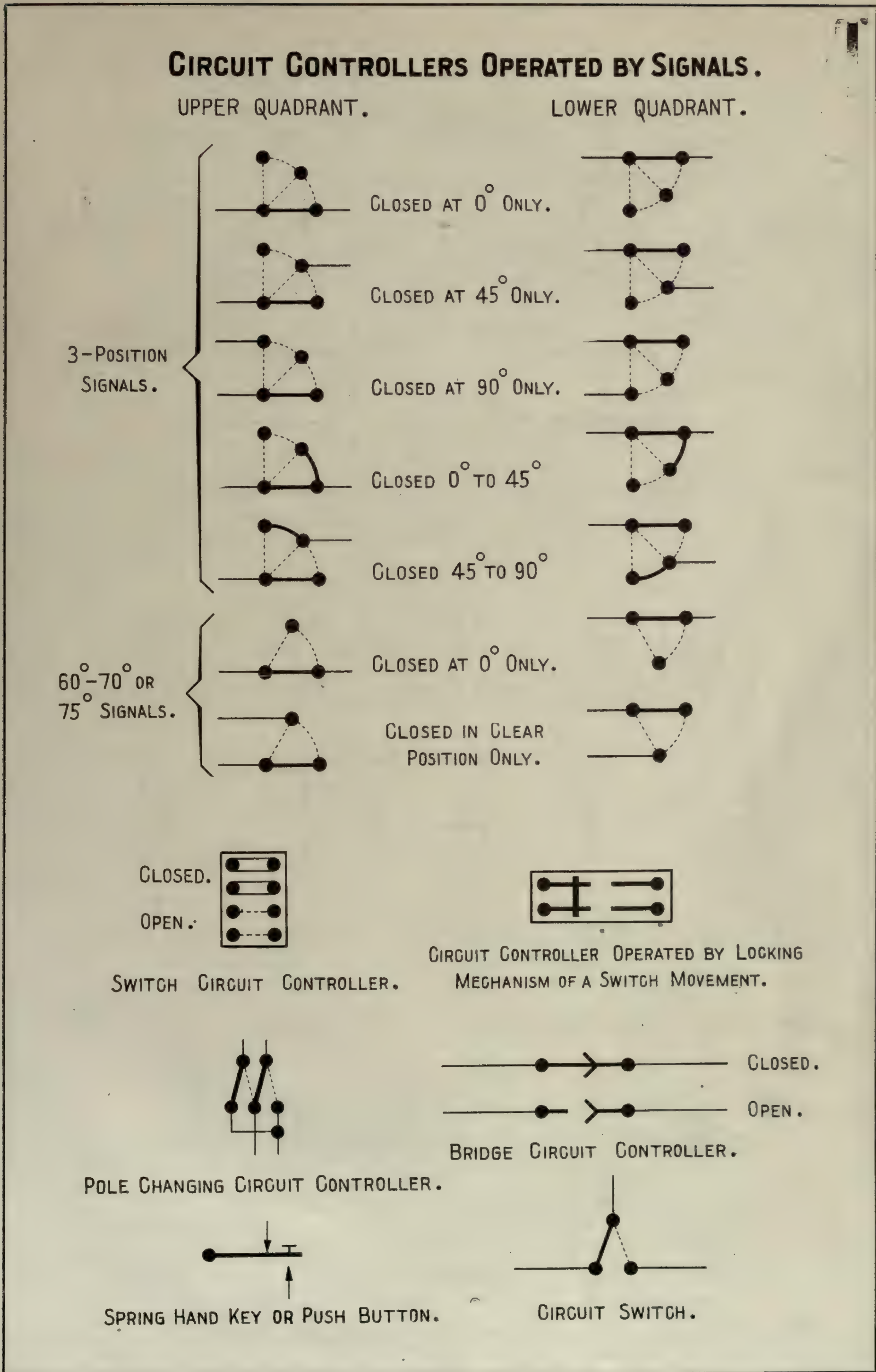
Levers with Middle Position as Normal.

N-Normal Position.
L-Full Reverse Position to the Left.
B-Indication Position to the Left.
D-Indication Position to the Right.
R-Full Reverse Position to the Right.

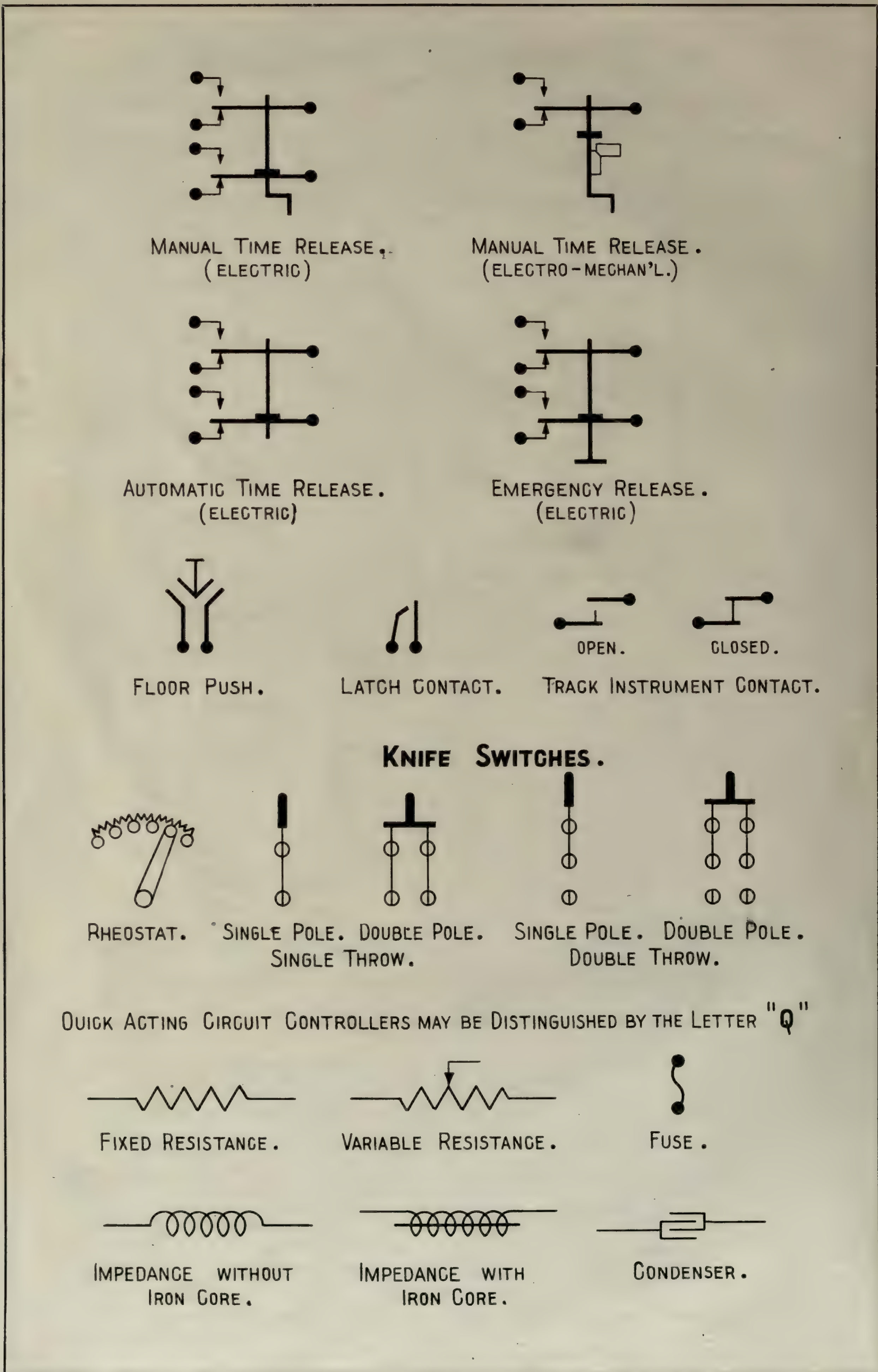


NOTE: Heavy horizontal lines indicate portion of cycle of lever through which circuit is closed.

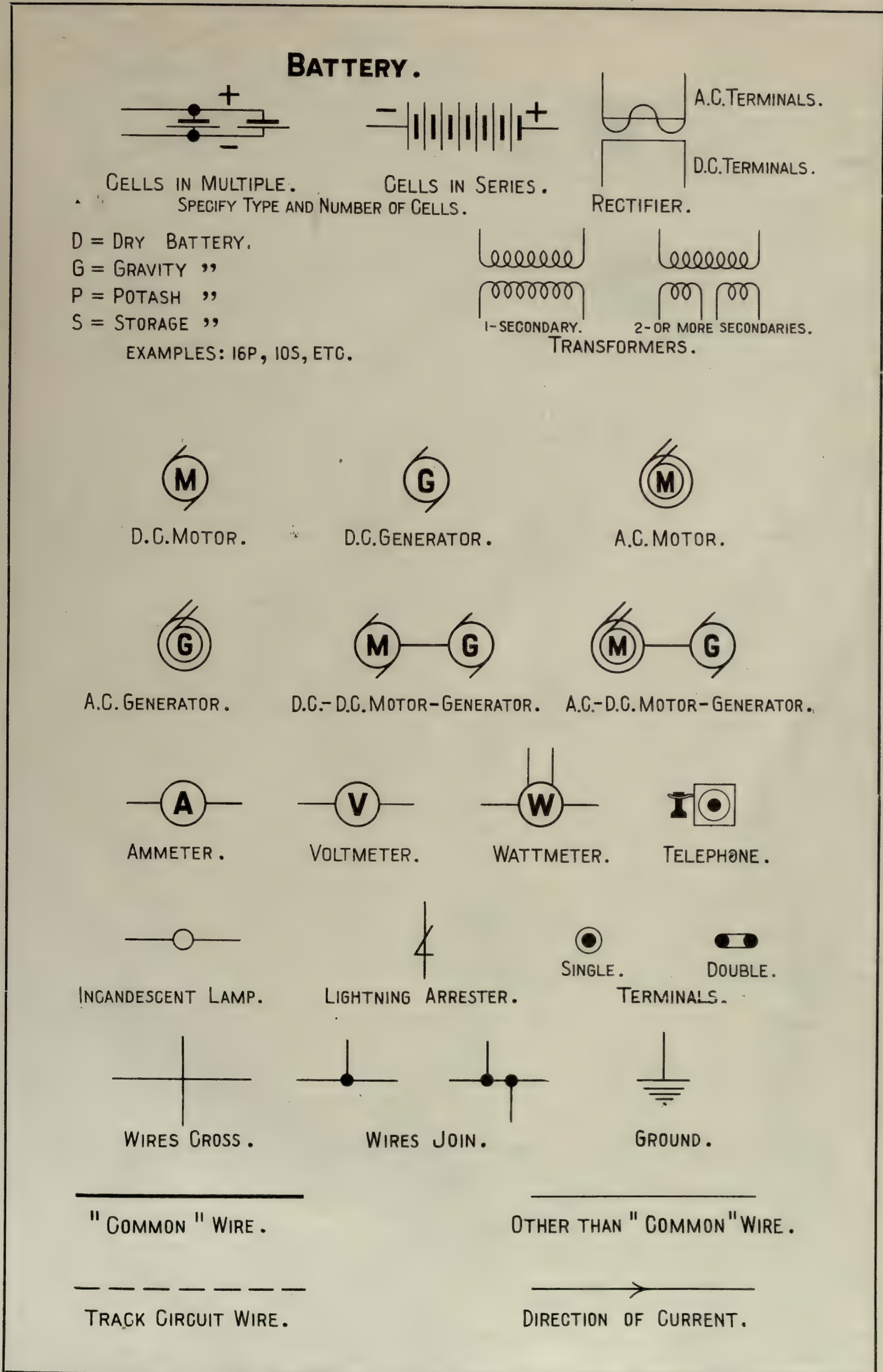
Figs. 169-170. Symbols for Circuit Plans (continued).



Figs. 171-181. Symbols for Circuit Plans (continued).



Figs. 182-200. Symbols for Circuit Plans (continued).



Figs. 201-224. Symbols for Circuit Plans (continued).

SEMAPHORE, BLOCK

Fig. 225. Square End Semaphore Blade. Used for Block and Interlocking Home Signals.

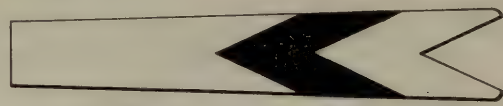


Fig. 226. Notched or Fish Tail Semaphore Blade. Used for Block and Interlocking Distant Signals.

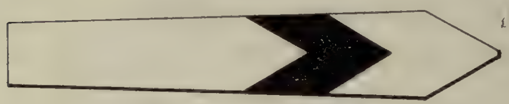
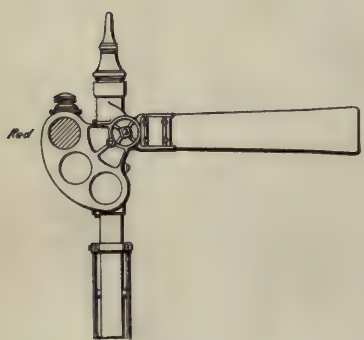
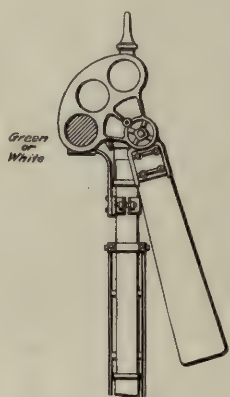


Fig. 227. Pointed End Semaphore Blade. Usually Used for Automatic Home Block Signals, or for Train Order Signals.

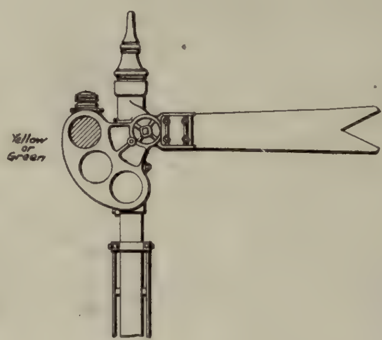
Fig. 228. Round End Semaphore Blade. Used for Train Order Signal, or Block Signal, or for Interlocking Signals Under Special Rules.



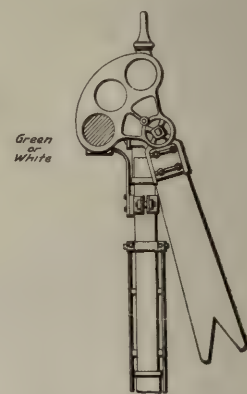
Stop, Block Occupied.



Proceed, Block Clear.



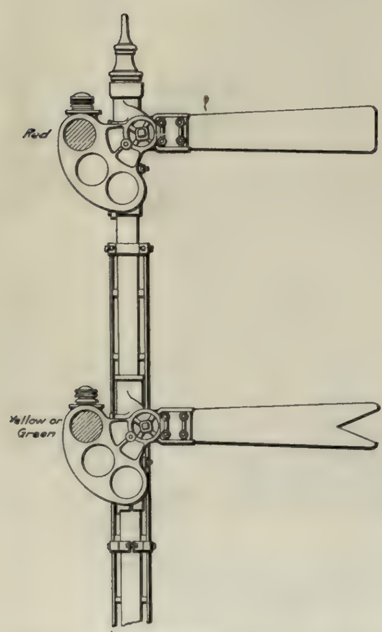
Caution, Prepare to Stop at Next Home Signal.



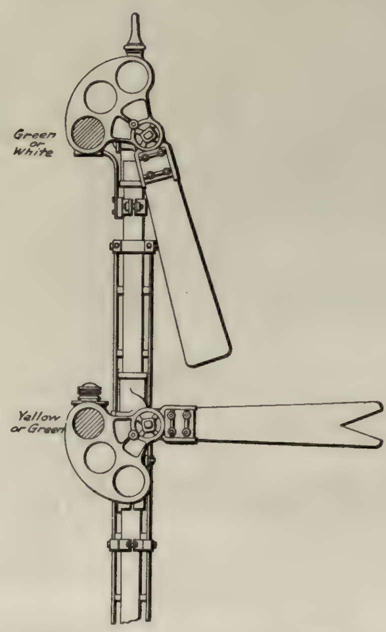
Clear, Next Home Signal at Proceed, Block in Advance Clear.

Figs. 229-230. Semaphore Home Block Signals, Two Position.

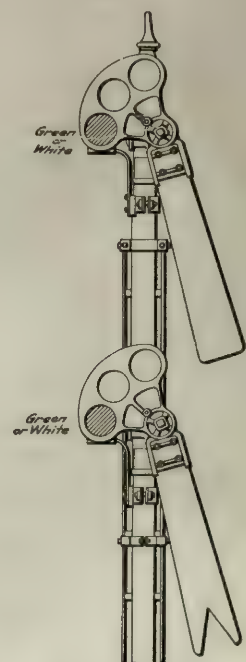
Figs. 231-232. Semaphore Distant Block Signals, Two Position.



Stop, Next Home Signal at Stop.

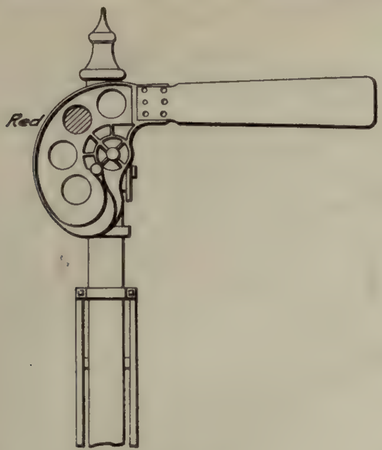


Proceed, Next Home Signal at Stop.

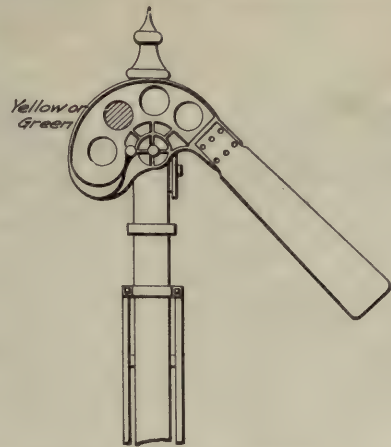


Proceed, Next Home Signal at Clear.

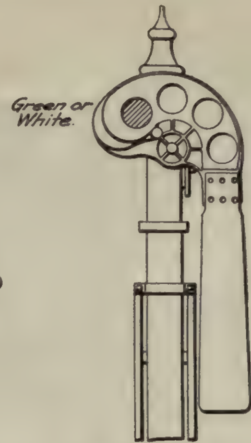
Figs. 233-235. Semaphore Home and Distant Block Signals on Same Post.



Stop, Block Occupied.

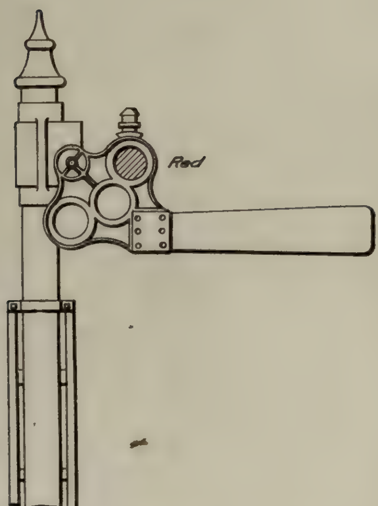


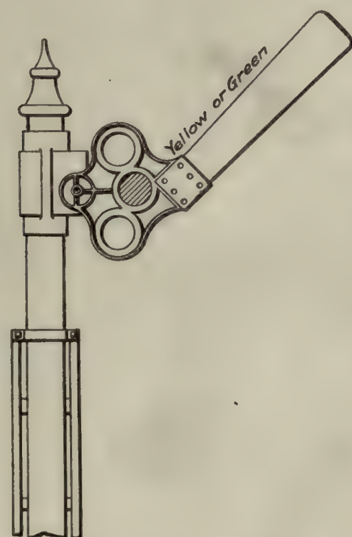
Caution, Block Clear, Next Signal at Stop.

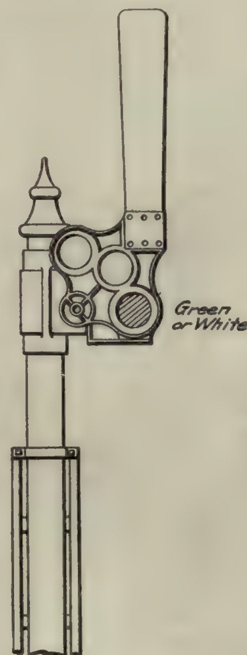


Clear, Block Unoccupied, Next Signal at Clear or Caution.

Figs. 236-238. Three-Position Semaphore Block Signal. Lower Quadrant Indications.







Figs. 239-241. Three-Position Semaphore Block Signal, Upper Quadrant Indication. The Indications Are the Same as the Corresponding Lower Quadrant Indications Shown in Figs. 236-238.

DISK, BLOCK

Stop.

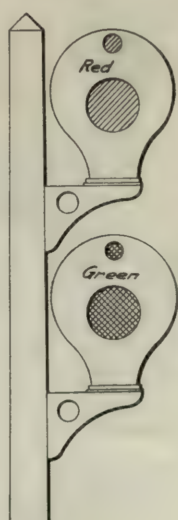
Proceed.

Figs. 242-243. Disk Home Block Signal.

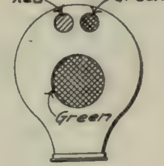
Caution.

Clear.

Figs. 244-245. Disk Distant Block Signal.



Figs. 246-247. Disk Home and Distant Signal on Same post. The Red Indicates Stop, the Green Indicates Be Prepared to Stop at Next Signal in Advance.

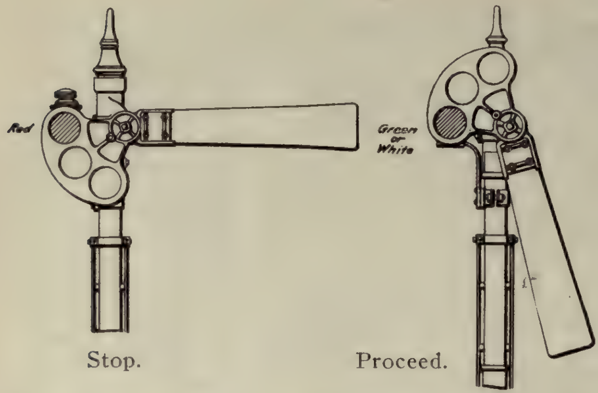


Caution.

Clear.

Figs. 248-249. Chicago & North-Western Two-Light Disk Distant Block Signal. The Red Light Is Obscured When the Signal Indicates Clear.

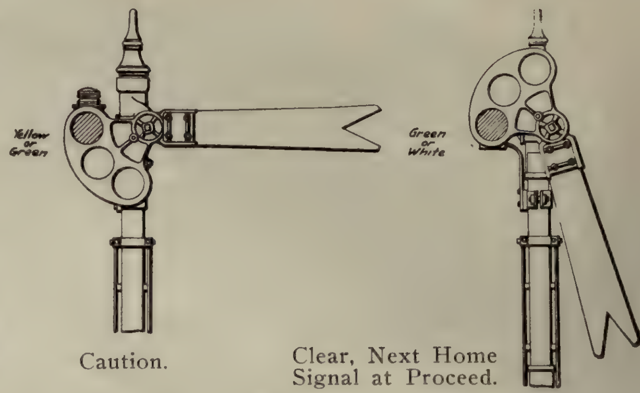
SEMAPHORE, INTERLOCKING



Stop.

Proceed.

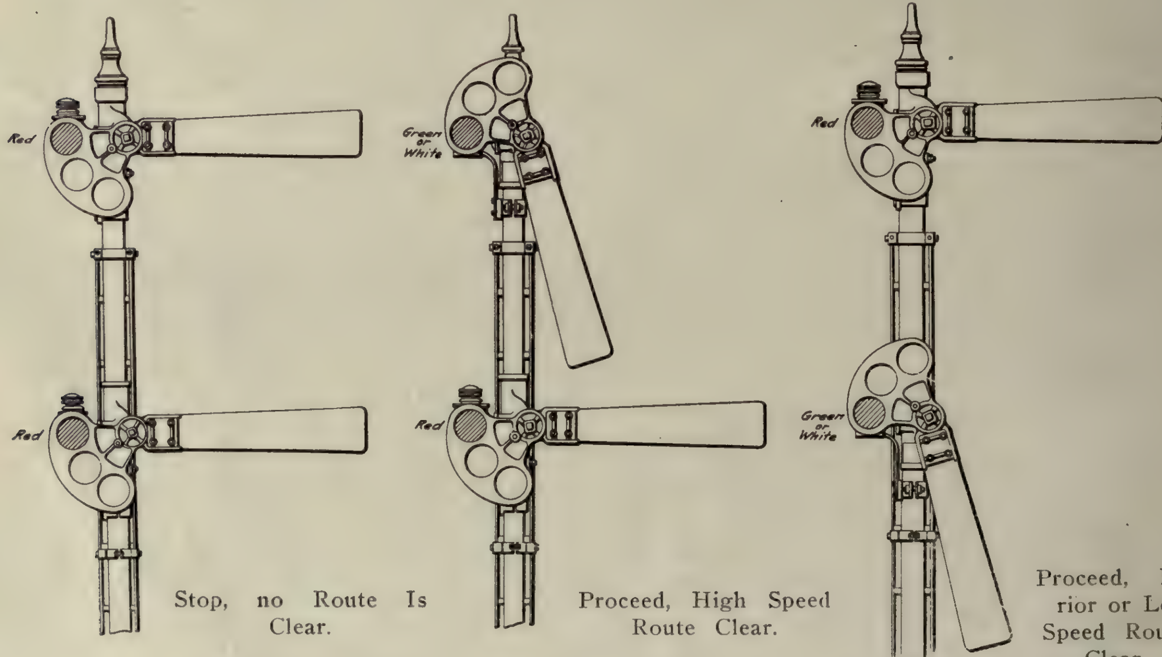
Figs. 250-251. One-Arm Semaphore Interlocking Home Signal.



Caution.

Clear, Next Home Signal at Proceed.

Figs. 252-253. One-Arm Semaphore Interlocking Distant Signal.

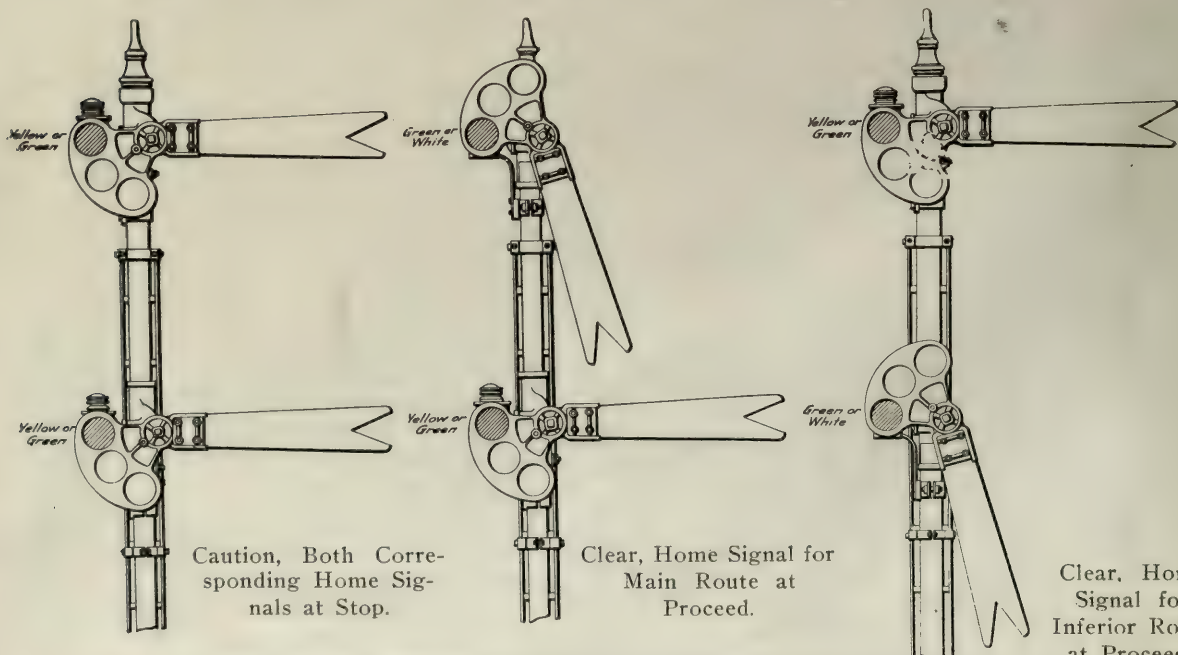


Stop, no Route Is Clear.

Proceed, High Speed Route Clear.

Proceed, Inferior or Low Speed Route Clear.

Figs. 254-256. Two-Arm Semaphore Interlocking Home Signals.

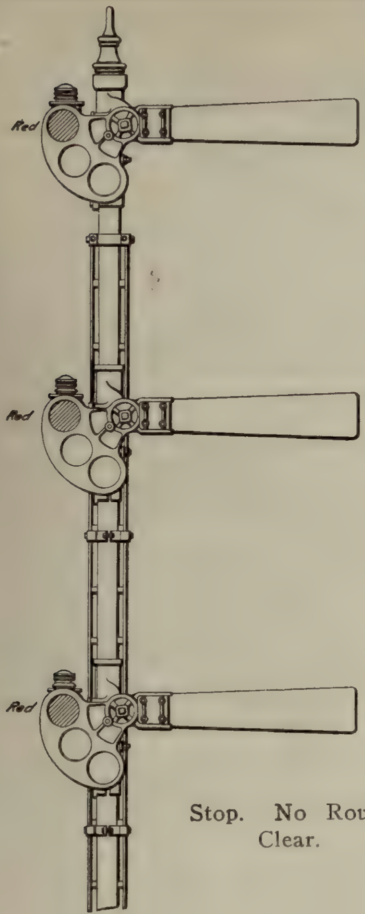


Caution, Both Corresponding Home Signals at Stop.

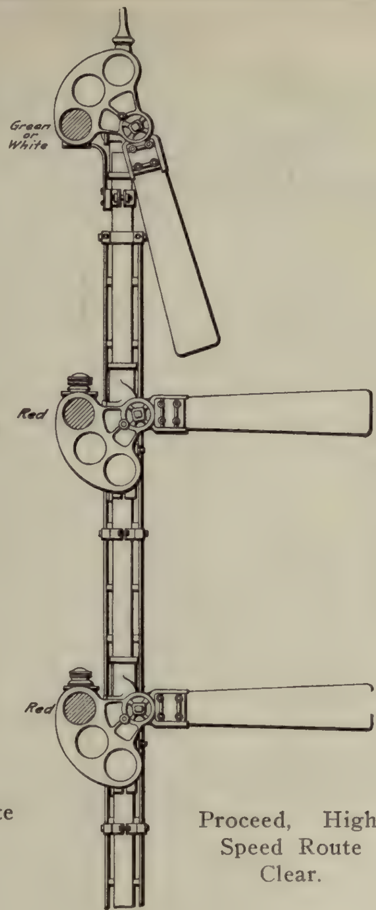
Clear, Home Signal for Main Route at Proceed.

Clear, Home Signal for Inferior Route at Proceed.

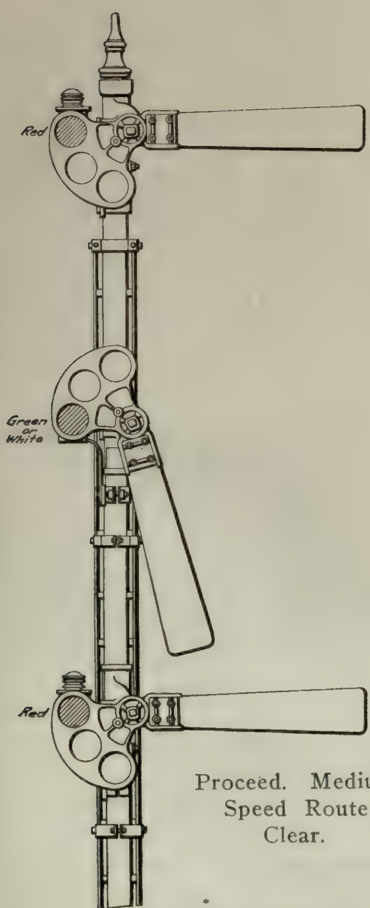
Figs. 257-259. Two-Arm Semaphore Interlocking Distant Signals.



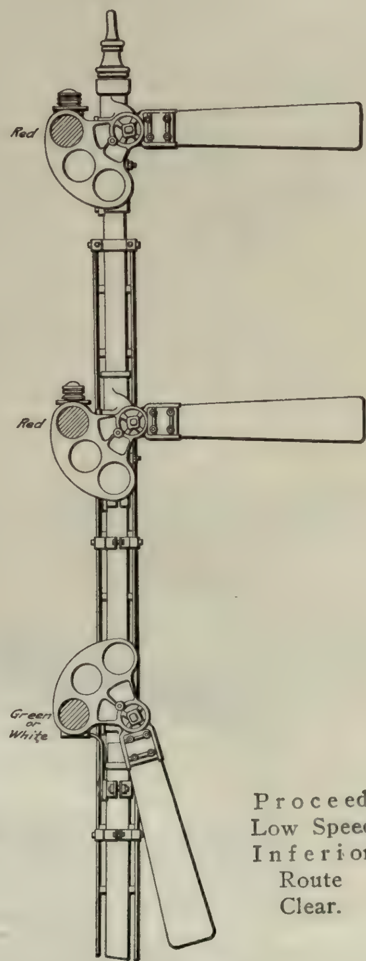
Stop. No Route Clear.



Proceed, High-Speed Route Clear.



Proceed. Medium Speed Route Clear.



Proceed, Low Speed Inferior Route Clear.

Figs. 260-263. Three-Arm Semaphore Interlocking Home Signals.

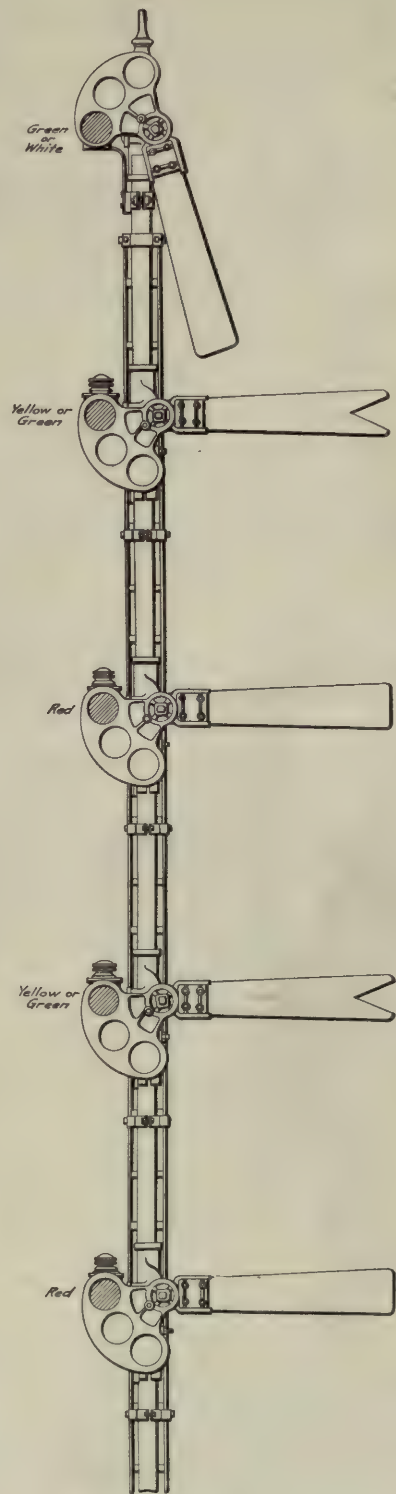
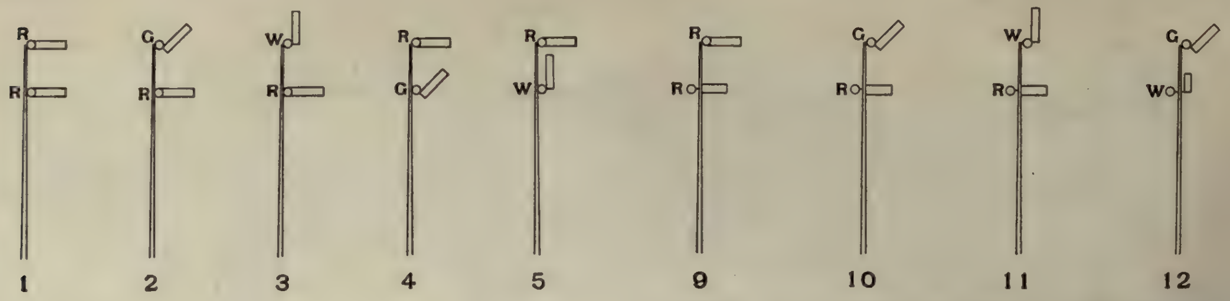
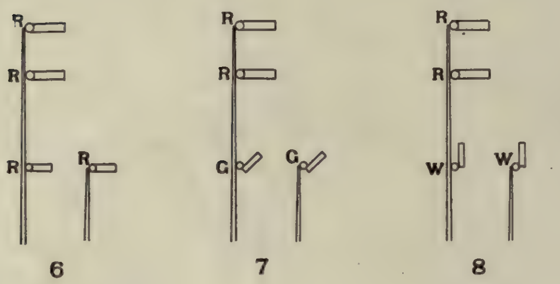


Fig. 264. Five-Arm Semaphore Interlocking Signal, with Home and Distant Arms; Indicating Proceed over High Speed Route.

The three home signal arms correspond with the three home signal arms shown in Figs. 260-263. Each distant signal arm gives indication for the next home signal on the same route as that for which the home arm immediately above it indicates.





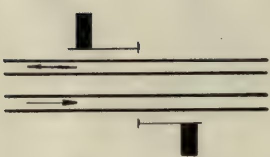
Numbers 1 to 8, inclusive, are Class "A," "Stop and Stay." The first five show indications for high and moderate speeds, and the other three show indications for low speeds, as follows: 1—Stop and stay; 2—Proceed with caution to next signal, on high-speed track; 3—Proceed at high speed, on high-speed track; 4—Proceed with caution to next signal, on moderate speed track; 5—Proceed at moderate speed, on moderate-speed track; 6—Stop and stay; 7—Proceed with caution, on low-speed track; 8—Proceed at low speed, on low-speed track. The lights are in a vertical line.

Numbers 9 to 12, inclusive, are Class "B," "Stop, Wait Time and Proceed" signals. These are for the automatic system and also for distant signals when the latter are used to give an independent indication; 9—Indicates stop, and proceed after waiting time; 10—Proceed to next signal, prepared to stop; 11—Proceed at full speed, next high speed signal at caution or clear; 12—Proceed at moderate speed; next moderate-speed signal at caution or clear. The lower light is staggered to the left.

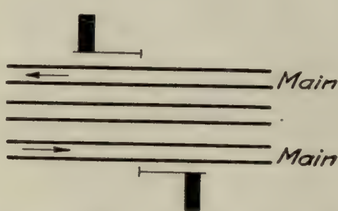
In all the figures R indicates a red light; G, green; W, white.

Figs. 265-276. Three-Position Upper Quadrant Block and Interlocking Signals, with Two High Arms, as Installed on the Central Division of the Philadelphia, Baltimore & Washington Railroad.

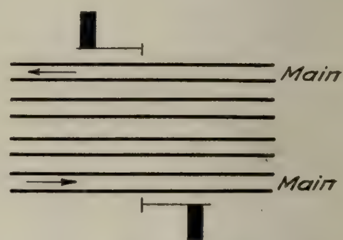
SIGNAL LOCATIONS WITH REFERENCE TO TRACKS GOVERNED



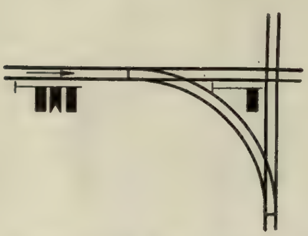
Double Track.



Three Tracks. Middle Track Not Signaled.



Four Tracks. Only the Two Outside Tracks Signaled.

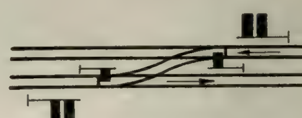


Two Home and One Distant Signal on Same Post.

Upper home governs direct route. Distant indicates position of home signal at crossing and lower home governs diverging route.

Trailing Point Crossover.

High signals govern main track movements in direction of arrows. Dwarf signals govern crossover and main track reverse movements. Signals and switches worked in conjunction with each other.



Facing Point Crossover.

Top arms of high signals govern main line movements in direction of arrows. Lower arms govern crossover movements. Dwarf signals govern reverse movements.

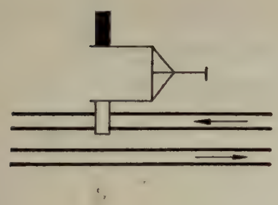
Trailing Point Siding Switch.

High signal at clear indicates switch set for main track in direction of arrow; at stop indicates switch may be set for siding. Dwarf signals govern movements into or out of siding, and reverse movements on main track.

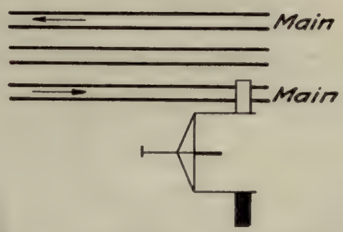
Diverging Routes.

Upper arm governs movements over the main route, middle arm over the next inferior route and lower arm over least important route, and may be made to indicate for any number of low-speed routes inferior to that governed by the middle arm.

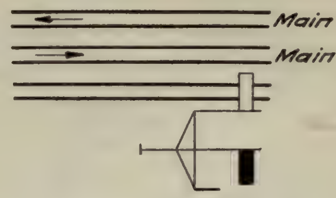
Figs. 277-284. Ground Post Signals.



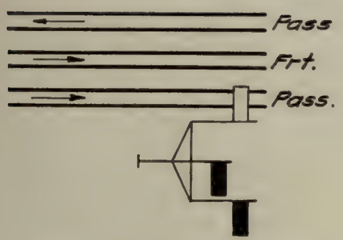
Double Track.



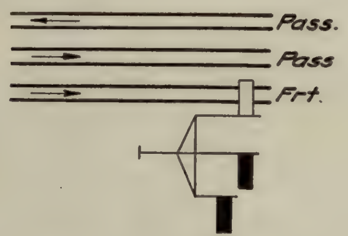
Three Tracks. Middle Track Not Signaled.



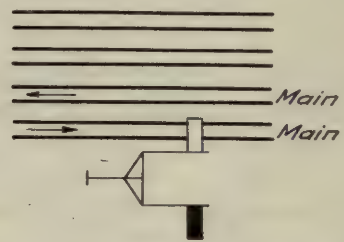
Three Tracks. One Outside Track Not Signaled.



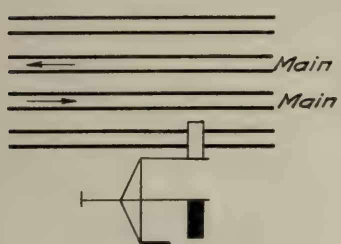
Three Tracks. Low Arm for Low Speed Track in Center.



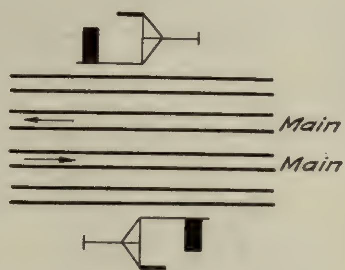
Three Tracks. Low Arm for Low Speed Track on Outside.



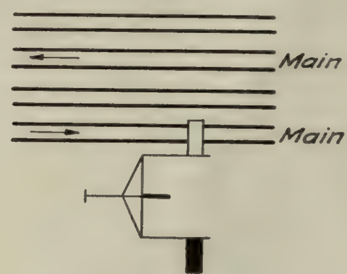
Four Tracks. Upper Two Tracks Not Signaled.



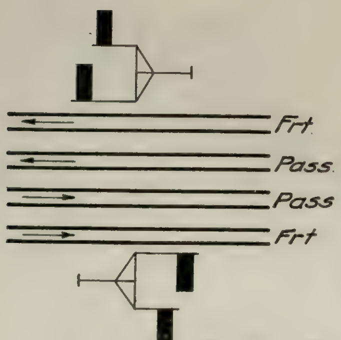
Four Tracks. Two Middle Tracks Only, Signaled. Dummy for Outside Track.



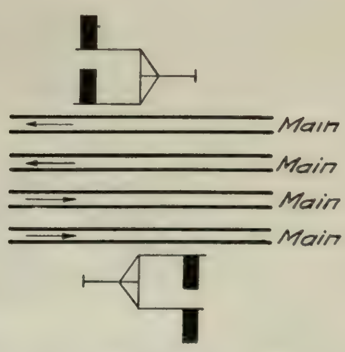
Four Tracks. Two Middle Tracks Only, Signaled. Dummies for Outside Tracks.



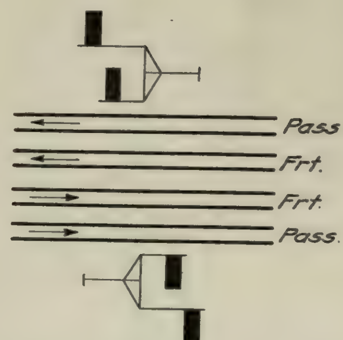
Four Tracks. Alternate Tracks Signaled. One Dummy.



Four Tracks Signaled. Low Arms Indicating Low Speed Movements on Outside Tracks.

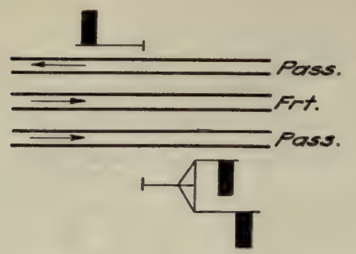


Four Tracks Signaled.

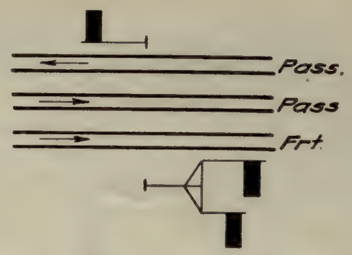


Four Tracks Signaled. Low Arms Indicating Low Speed Movements on Middle Tracks.

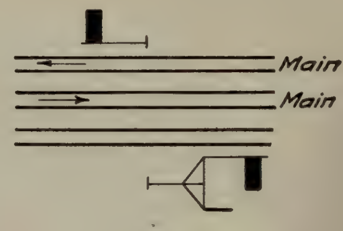
Figs. 285-296. Bracket Post Signals.



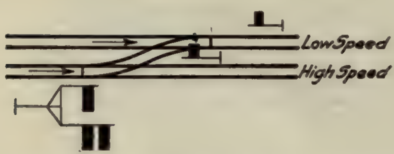
Ground Post Signal for High Speed Track on Outside; Bracket Post with Low Arm for Middle Track Used for Low Speed Movements, and High Arm for Outside Track.



Ground Post Signal for High Speed Track on Outside; Bracket Post, with High Arm for Middle Track, and Lower Arm for Freight or Low-Speed Track on Outside.



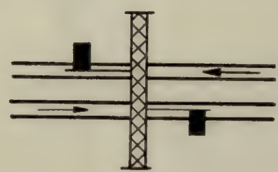
Ground Post Signal and Bracket Post Signal for Outside and Middle Track. Dummy on Bracket Post to Indicate Other Outside Track is Not Signaled.



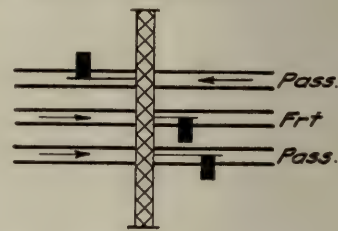
Crossover from High Speed Track to Low Speed Track.

The single arm is for low-speed track, there being but one possible normal movement on that track. The double arm high signal governs the high speed track, the top arm for straight movements and the lower arm for crossover movements. The dwarf signals govern reverse movements.

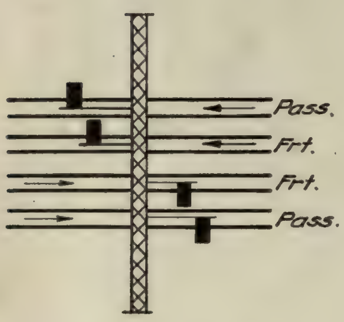
Figs. 297-300. Ground Post and Bracket Post Signals.

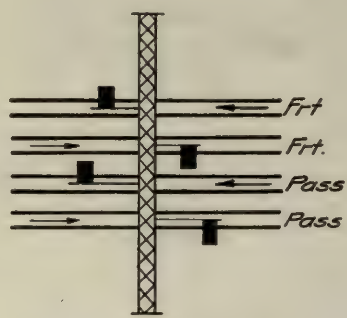


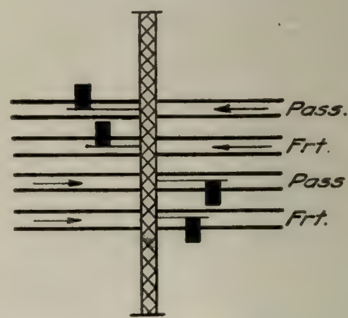
Signals for Both Tracks Mounted on Bridge Over Tracks.



Three Tracks. Low Signals For Low Speed Track in Center.

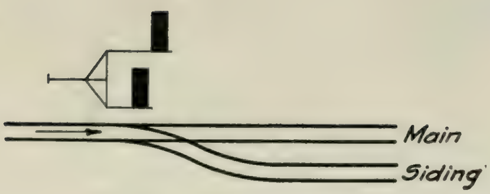




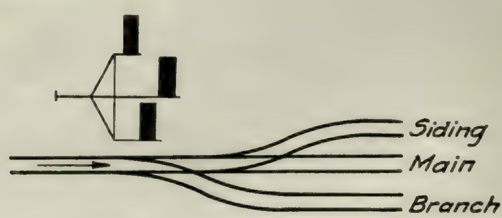


Four Tracks Signaled. All Signals Mounted on Bridges. Low Signals for Low-speed Tracks. Three Different Arrangements of Tracks.

Figs. 301-305. Bridge Signals.



Diverging Routes.



One Main and Two Diverging Routes.

Figs. 306-307. Typical British Arrangement of Signals.

A bracket post is used, having a doll for each arm; the arm governing movements over the main route is mounted higher than other arms. An arm governing diverging movements is placed on the corresponding side of the main route arm.

BLOCK SIGNALS

Pages 22-132 Figures 308-739

TYPICAL ARRANGEMENTS

Fig. 308. Block A to B. Train in Block. Protected by Signal A in rear, Indicating Stop to Following Train.

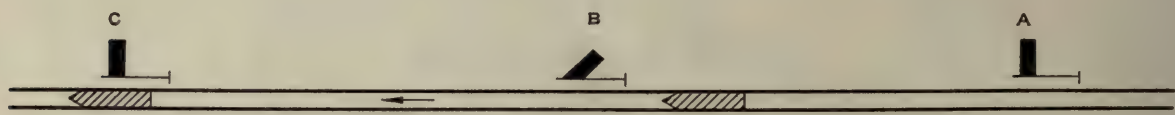


Fig. 309. Blocks A to B, and B to C. Train Has Just Passed Signal C. Signal B is Clear for Next Train to Pass B Toward C.

Fig. 310. Home and Distant Block Signals. Block H1 to H2. Distant Signals D1 and D2 Give Preliminary Information as to Indication at Next Home Signal. Train in Block. H1 and D1 Indicate Stop and Caution Respectively, Protecting Following Train.

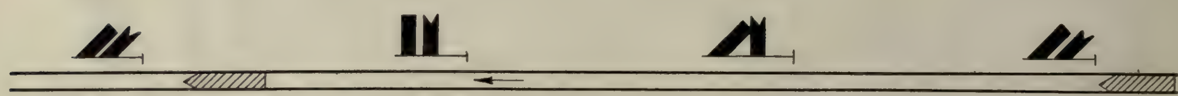


Fig. 311. Home and Distant Signals. Distant Signal Mounted on Same Post with Home Signal in the Rear.

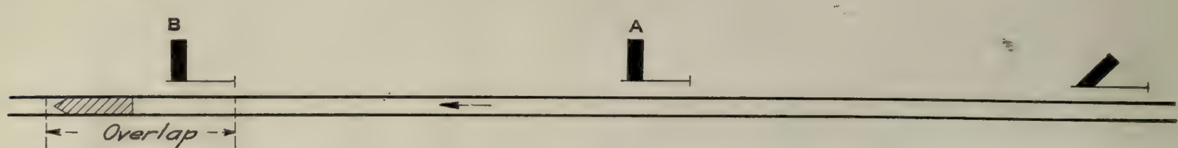


Fig. 312. Block Signals With Overlap. Block A to B. Signal A Indicating "Stop" Behind a Train Cannot be Cleared Until That Train Has Passed Beyond the Overlap.

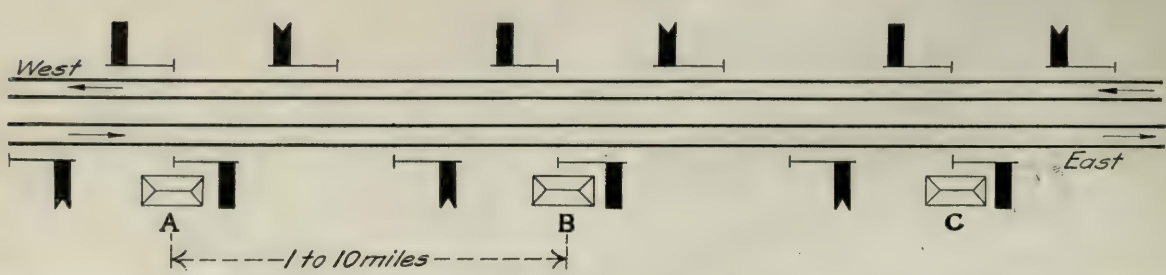


Fig. 313. Manual Block Signals on Double Track Railway. Blocks A to B and B to C. Signalmen Stationed in Cabins Communicate by Telegraph, Telephone or Bell, Ascertaining if Block Ahead is Clear Before Allowing Train to Pass by Setting Home and Distant Signals at Clear.

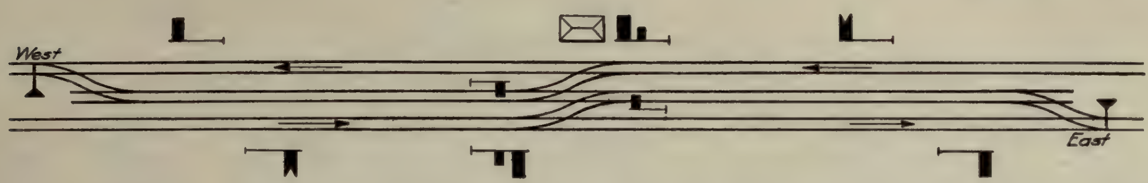


Fig. 314. Middle Passing Track at Manual Block Stations on Erie Railroad.

Switches near cabin operated by levers in cabin interlocked with signal levers; outlying switches have electric locks controlled from cabin. Passing track about 8,000 ft. long.

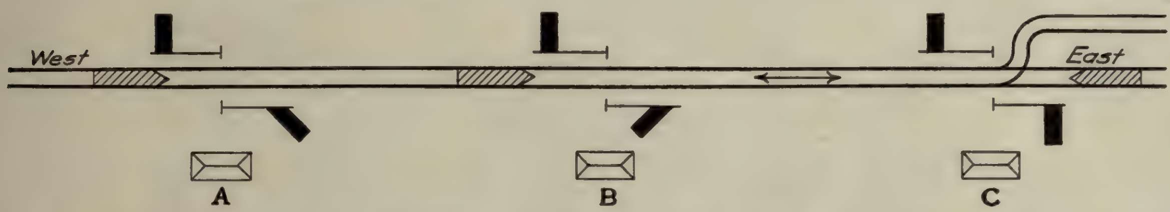
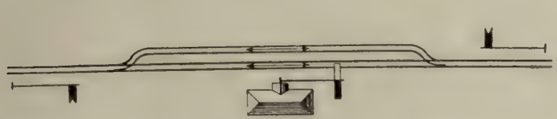
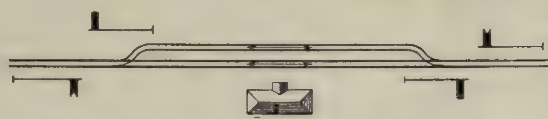


Fig. 315. Three-Position Arm for Permissive Blocking on Single Track Roads. Signal A Indicates Caution; Signal B, Clear; Signal C, Stop.



Home Signals for East and West Movements on Same Post at Station.



Home Signals on Separate Posts Beyond Station.

Figs. 316-317. Manual Block Station on Single Track Roads. Switches Not Controlled from the Station. Many such stations have no distant signals.

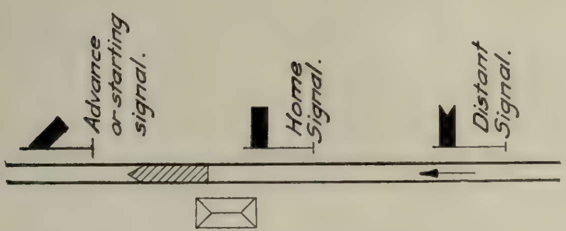
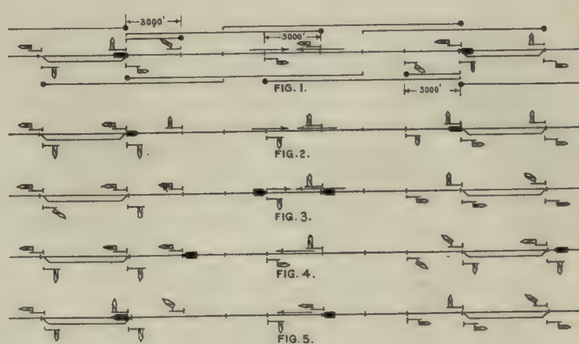


Fig. 318. Distant, Home, and Advance Signals at Manual Block Station.

Where the home signal is at or near a station platform a train may be allowed to pass the home signal, but be held at the advance signal until the block ahead is clear. In effect a short intermediate block is formed, in which a train may be held without delaying a following train entering the block at the next block station in the rear.



Figs. 319-323. Northern Pacific Scheme of Automatic Signaling on Single Track.

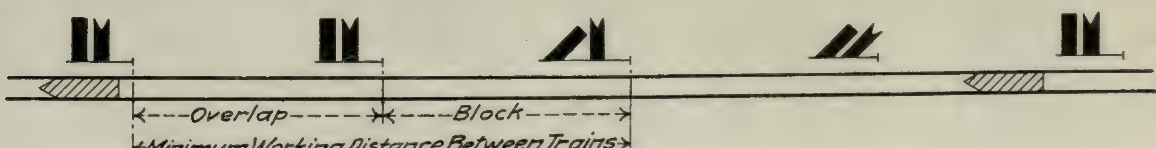


Fig. 324. Automatic Block Signals With Overlap in New York City Subway.

The overlap is made the length of a block and the blocks as short as possible. (About 25 per cent. longer than the distance required for an emergency stop for trains running at maximum speed.) Automatic train stops are used at each home signal. A train is always protected by two home signals indicating stop behind it and by a distant signal indicating caution one block behind the second home signal. The distance between trains running at full speed must be more than three blocks.

MANUAL

COMMUNICATING MECHANISMS

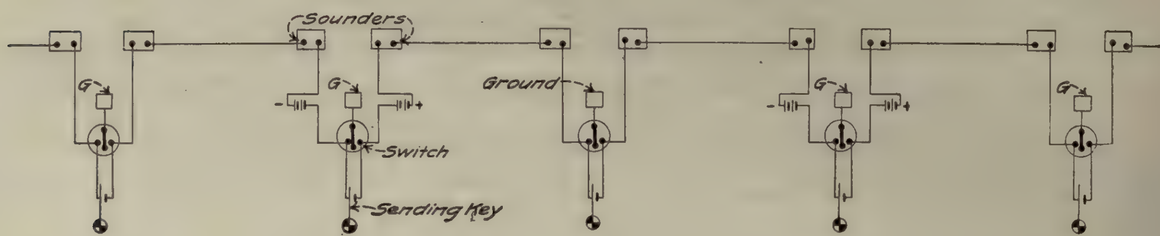


Fig. 325. Morse Telegraph Circuits Between Block Stations, with Line Battery at Alternate Stations.

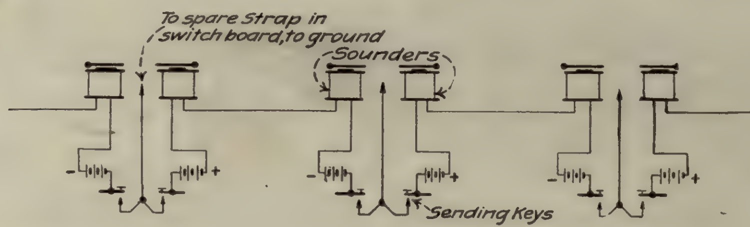


Fig. 326. Morse Telegraph Circuits Between Block Stations, with Line Battery at Each Station.

NOTE.—When line is more than 20 miles long, relays working sounders on local circuit must be used in either arrangement shown.

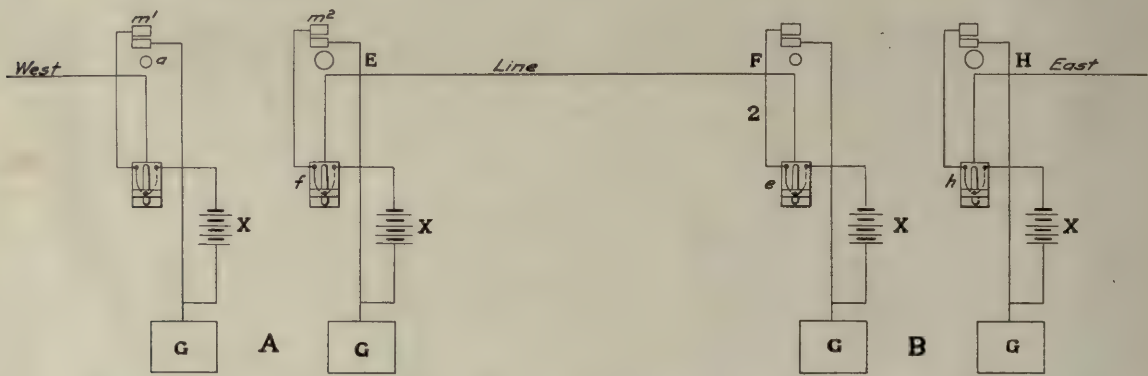
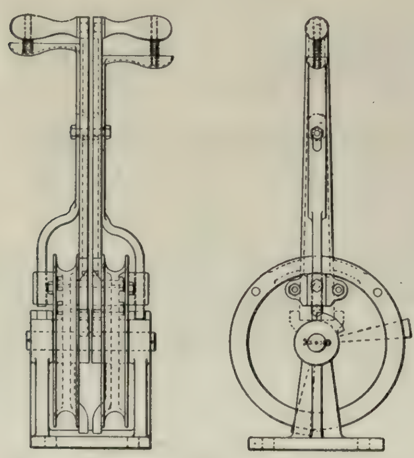


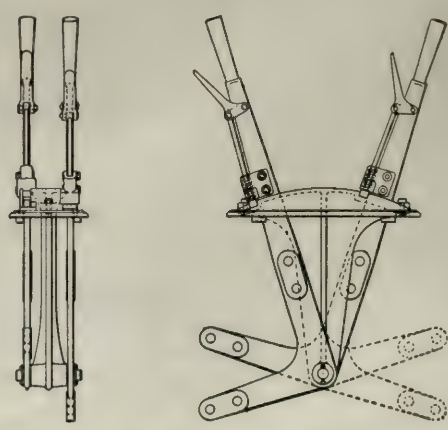
Fig. 327. Communicating Bell Circuits for Manual Block Stations; Erie Railroad.

A presses key *f* which closes circuit from battery X at A through contact of key *f* (now closed), line, normally closed contact of key *e* at B, wire 2, bell F to ground G. When B presses key *e*, bell E at A rings through similar circuit. Each station has bell and key for eastbound and westbound communication.

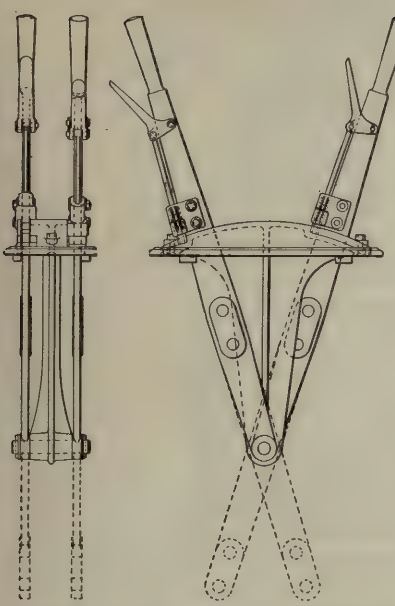
LEADOUTS



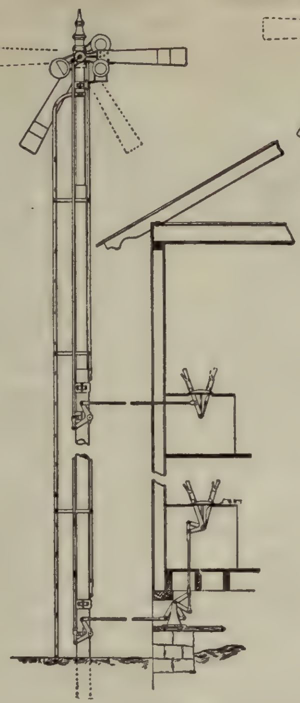
Figs. 328-329. Signal Levers.—Two Lever, Two-Position Wall or Table Lever Machine with Chain Wheel Attachment. The Union Switch & Signal Company.



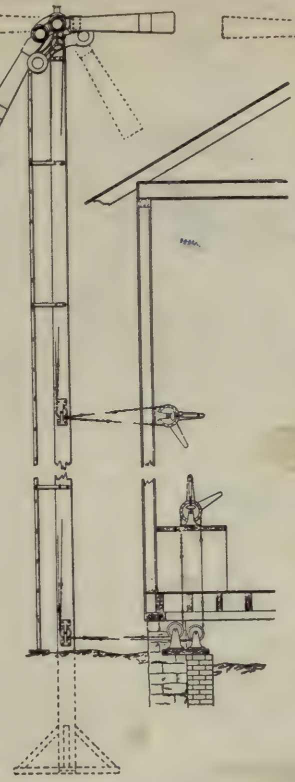
Figs. 330-331. Signal Levers.—Two Lever, Two-Position Table Lever Machine for Vertical or Horizontal Pipe or Wire Leadout. The Union Switch & Signal Company.



Figs. 332-333. Two-Lever Two-Position Table Lever Machine for Horizontal Pipe or Wire Leadout. The Union Switch & Signal Co.



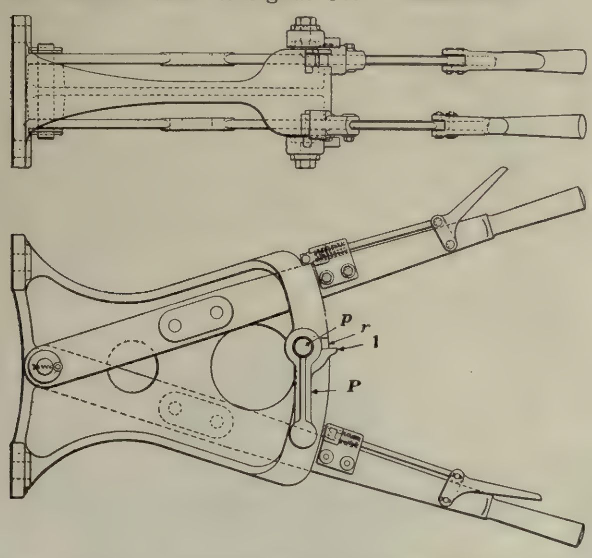
Vertical and Horizontal Pipe Leadouts for Table Machines.



Chain Wheel and Wire Leadouts for Wall and Table Machines.

Vertical and Horizontal Wire Leadouts for Wall and Table Machines.

Figs. 336-338. Leadout Connections from Manual Block Stations to Signals.



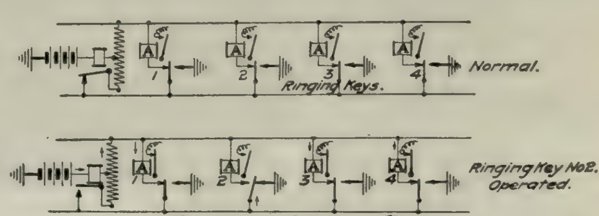
Figs. 334-335. Three-Position Horizontal Wall Lever Machine for Vertical Lead-out. The Union Switch & Signal Co.

HORIZONTAL WALL LEVER MACHINE.

The pendulum P lies normally in the vertical plane as shown in Fig. 335. When the signal lever is returned from its lowest or clear position, its latch impinges on the lower side of the lug 1, rotating it around the pivot p, and past the center notch r, thus preventing the lever latch from falling into the notch. This compels the signalman to complete the travel of the lever and thus return the signal to "stop" before again clearing it. As soon as the lever has passed the center notch, the pendulum P falls back to its normal position by gravity.

ENGLISH PRACTICE IN MANUAL SIGNALS

The usual telephone instruments are installed in each block station, being connected across a pair of continuous line wires as shown in Fig. 342. A common ringing battery is installed at one station which supplies current when required for energizing the relays, A, used to cut in the call bells operated from local battery. In order to economize ringing battery current and to cut down noise on the line from induced current an arrangement of impedance coil and cutting-out relay is used with the ringing battery. The operation of this device is shown in Figs. 339-340. The battery is connected to ground on one side and through the relay on the other side to the center of the impedance coil. This coil is connected across the line wires, direct on one side and through a back contact of the cutting-out relay on the other side. When any ringing key is closed, as at 2, Fig. 340, a path is closed to ground from the lower line wire. Current flows from ringing battery on upper line wire through all the bell relays A, except that at 2, across the line and through lower line wire toward 2, where connection is made with ground. No current flows direct from battery to ground over lower line wire, because the cutting-out relay is energized by the current flowing through the upper line wire and opens the back contact to lower line wire. All of the bell relays A, except that at 2, are energized and the bells ring simultaneously, the circuit being from local battery



Figs. 339-340. Method of Operation of Telephone Ringing Key.

through the bell, closed on relay A, ringing key terminal, back to battery. As soon as the ringing key at 2 is opened again, the path to ground is broken, all bell relays A are de-energized,

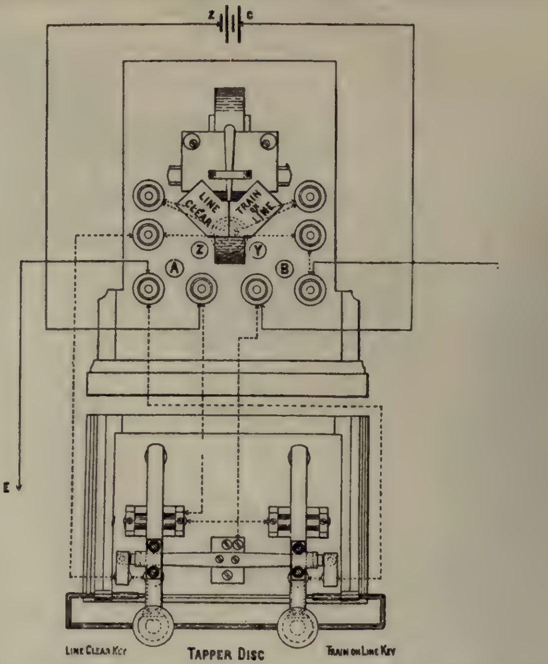


Fig. 341. Indicator Block Instrument, Great Western Railway of England.

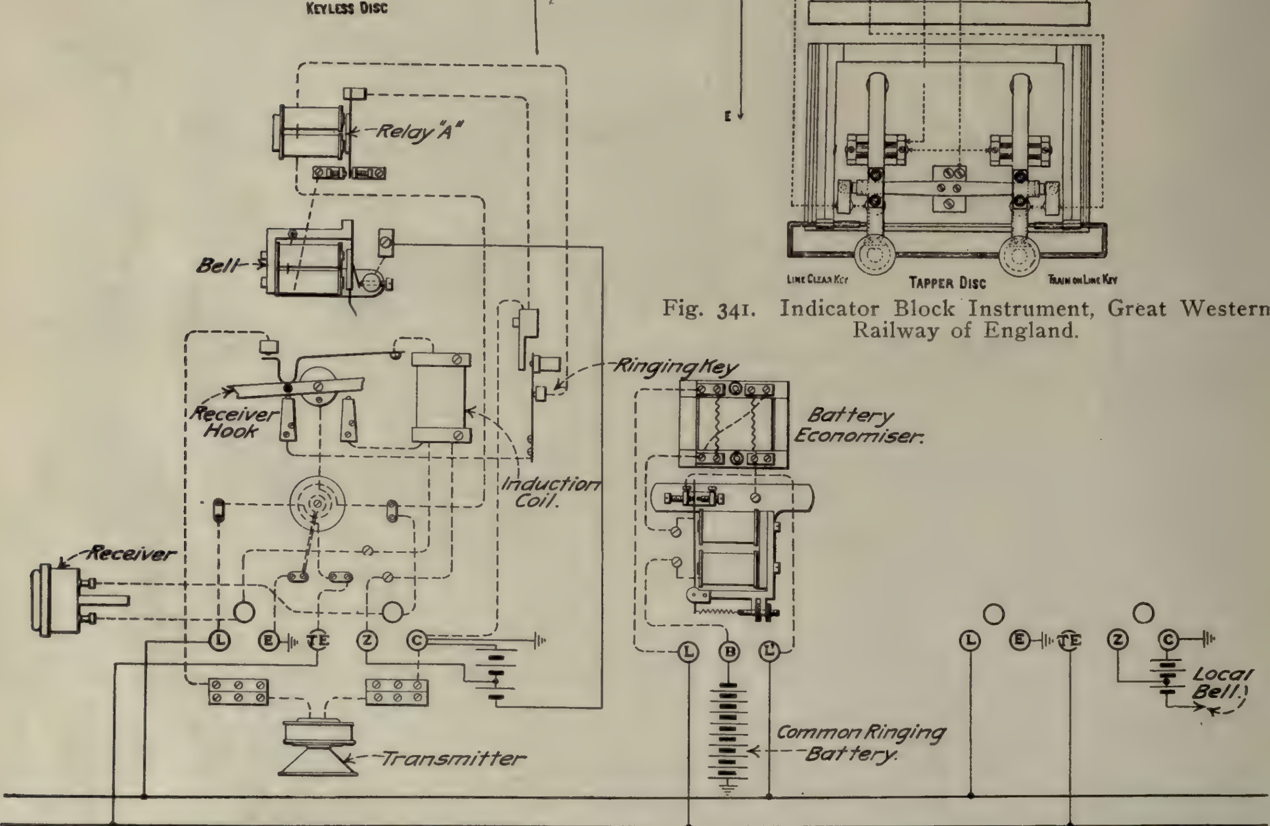
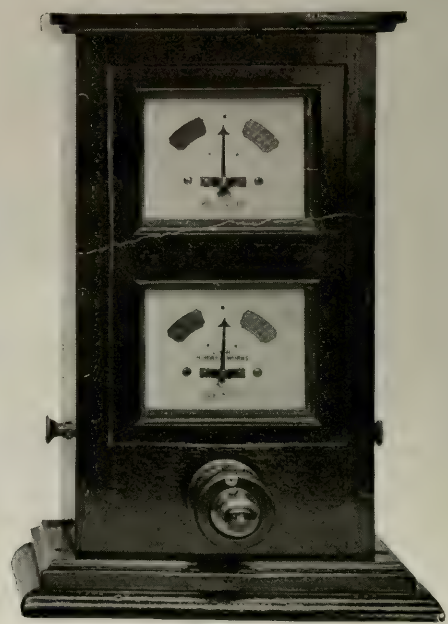


Fig. 342. Telephone Communicating Circuits Between Block Stations, Great Western Railway of England.

Instrument Open.



Instrument Closed.

Figs. 343-344. Repeating Block Instrument, Lancashire & Yorkshire Railway.

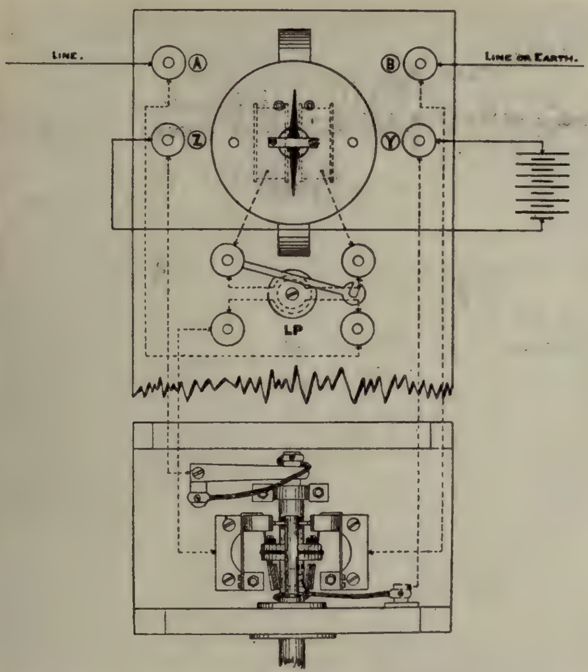


Fig. 345. Single Needle Block Instrument, Great Western Railway of England.

the bells cease ringing, and the cutting-out relay drops to its normal position, as shown in Fig. 339. The impedance across the line at the ringing battery permits induced currents to pass equally from each line to ground, and prevents noise on the telephone circuit. The bell relays A are of high resistance and are not affected by the current flowing on the telephone circuit.

The block instrument commonly used in Great Britain for communicating between block stations is essentially a galvanometer, having a rotating armature mounted between two coils of wire. When current flows through the coils in one direction the armature tends to rotate to the right and when the direction of flow of current is reversed the armature rotates to the left. When no current flows, the armature returns to a neutral position in the center. The armature may carry a printed disk or indicator as in Fig. 341, or simply a needle, as in Figs. 341 and 345. The needle instrument (Fig. 345) may be used as a speaking telegraph also, movements of the needle to the right or left corresponding to the dots and dashes of the Morse code. Sending is done by pressing down the "line clear" key or the "train on line" key (Fig. 341), or by turning the knob (Fig. 344) to the right or left. This reverses the polarity of the current by changing the connections of the battery between line and ground.

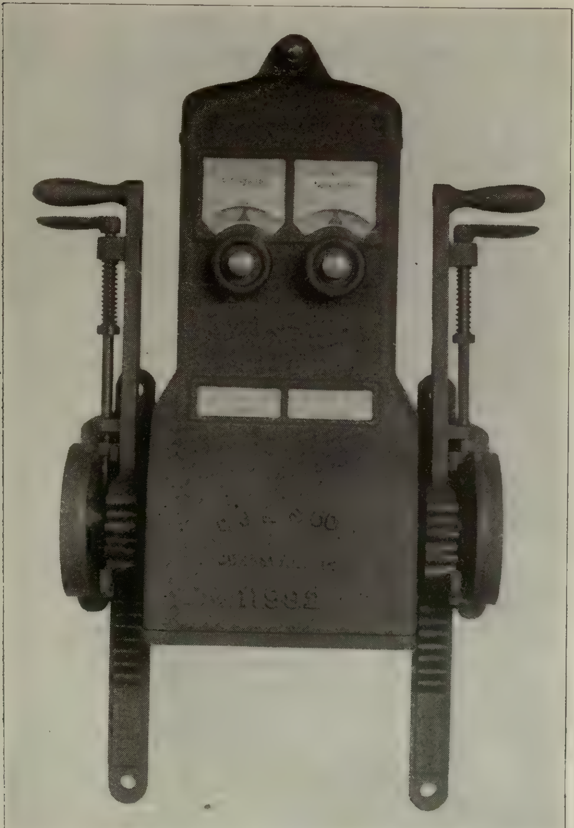
When a signalman, say at B, gives a "line clear" signal to the station in the rear, say A, he fastens his indicator in the "line clear" position, thus keeping before him a visual indication of what he has done. As soon as the station in the rear (A) reports the starting of the train, the signalman at B puts his indicator in the position showing "train on line" and fastens it there. In like manner the signalman at B fastens his indicator, after sending any signal over the wire to C, thus having before him constantly a visual indication of the movement last made.

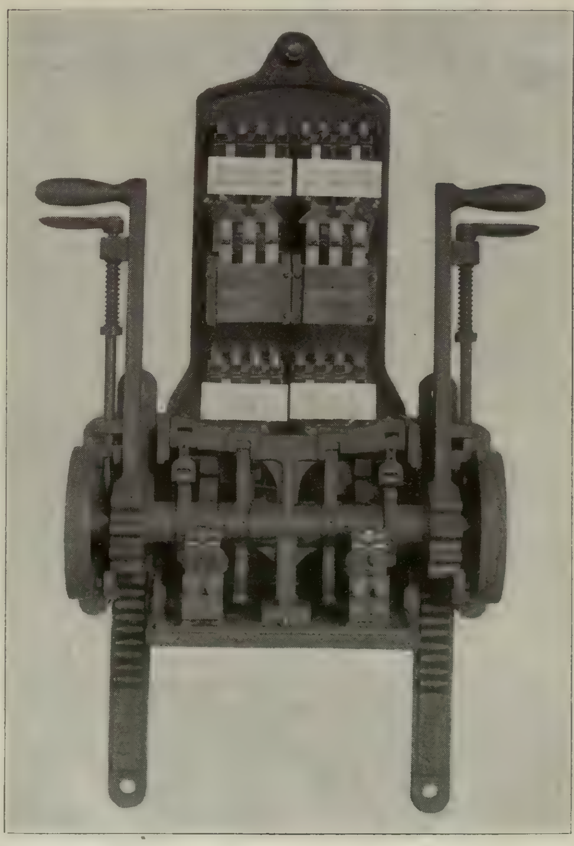
CONTROLLED MANUAL

U. S. & S. ELECTRO-MANUAL SYSTEM.

The principle on which all controlled manual block systems are operated is that before any signal can be displayed to admit a train into a block, the co-operation of two persons, one located at each end of the block, is necessary. This result is obtained by electrically controlling the levers operating the block signals; the electric control being so devised that each signalman must perform certain prescribed manipulations before any signal can be cleared by the signalman at either end of the block.

In the Union electro-manual system, the operating levers and the mechanical and electric devices which control them are combined in one compact instrument, views of which are shown in Figs. 346-347. The instrument is secured to the wall of the office in which it is located and the mechanical connections between it and the signals it operates are attached to one or the other end of the racks operated by the levers.





Figs. 346-347. Union Electro-Manual Block Instrument.

The instrument shown is such as is used at intermediate block stations and consists of two complete and independent levers, their controlling devices and indicators. The lever and its controlling devices located on the right of the instrument govern the block to the left, and the lever on the left governs the block to the right.

Both the mechanical and electric locking of the instrument is applied to the latch instead of the lever as is ordinarily the case, thus greatly minimizing the strain which it is possible to apply to such locking and furthermore insuring that the locking is operated before any movement can be given to the lever.

The operating lever can be returned to the normal position directly from any other position.

The instrument can be used with or without track circuit control; in other words, if originally installed without the use of track circuits, these can be added later by simply modifying the external wiring, no changes being necessary in the instruments themselves.

A combined plunger and push button is provided for transmitting bell signals for giving a release to the signalman at the opposite end of the block.

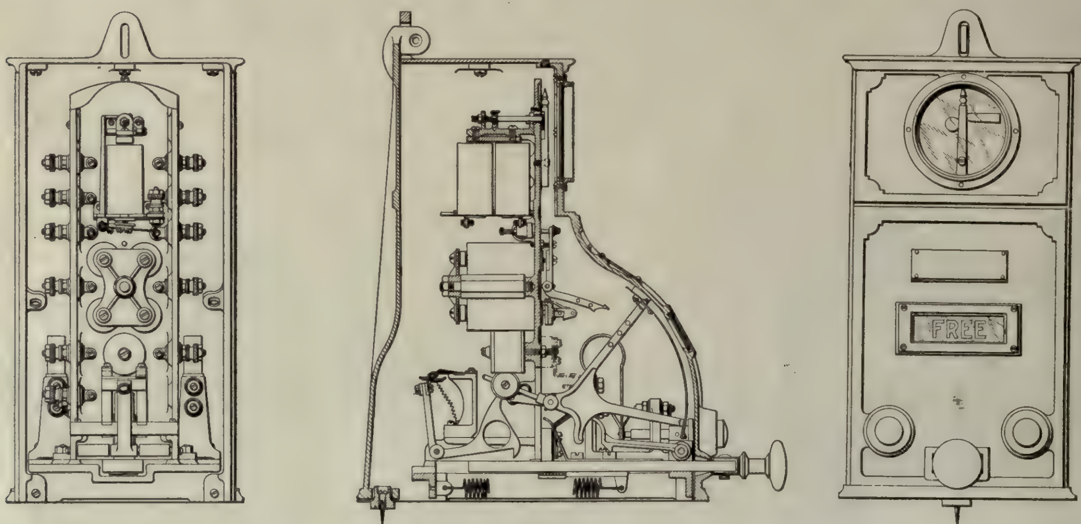
When a signalman at one end of the block has given a release to a signalman at the opposite end, the former cannot take it away again without the consent of the latter, although the signalman receiving the release might not have used it to clear his signal.

The instrument illustrated is designed for two-position signals, but can be modified to operate three-position signals.

COLEMAN "LOCK AND BLOCK" SYSTEM.

The Controlled Manual or "Lock and Block" instruments, made by the Union Switch & Signal Co., are an improved form of the Sykes instrument and accomplish all and more than the original Sykes instruments which were imported from England. The Sykes system, as originally installed in the United States, used only one home signal and a distant signal at each block tower for each track. This arrangement is still used in many cases where there are no switches at or near the block

Fig. 348. Location of Lock and Block Instrument Over Interlocking Machine.



Figs. 349-351. Coleman Lock and Block Instrument; Parts in "Free" Position.

tower. In practice, however, it often has been found convenient to use an advance block signal in addition to the home signal, in order to conveniently permit trains to use the switches situated between the home and the advance block signal, and to expedite the movement of trains from block to block when traffic is heavy. On the New York Central advance block signals have been installed at nearly all block towers where there are switches and at some few other towers where there are no switches. Where no advance block signal is used, the locking up track circuit and the plunger-release track circuit are combined in one.

Fig. 352 shows the operation of the Coleman instruments for double track, with home and advance block signals, as installed on the New York Central. In this installation the advance or starting signal is known as the block signal. A train occupying track between signals H and B at tower X is to proceed to tower Y. The signalman at X calls Y by bell and asks for an "unlock." If the preceding train has cleared the block at Y and the instruments are normal, as shown in the diagram. Y pulls out the plunger as far as it will go, thereby raising his banner to show "locked." This closes the contact shown below coil 46. To insure signal H at Y being blocked and the terminal block track circuit unoccupied, a preliminary circuit is provided from battery wire 101, through binding post 1, coil 46, coil 47, binding post 9, wire 17, contact 1 on home lever roller, wire 14, front contact on terminal block relay, to common return wire 100. If the two conditions are fulfilled, this circuit is completed, energizing magnet 46 and holding up the banner to show "locked" by the latch of 46. Y then releases his plunger, which is returned to its normal position by a spring. When the plunger completes its return stroke, the latch shown back of the banner drops into a notch in the plunger bar (or slide) and locks it in the normal position, at the same time breaking the contact between 46 and 47. But before this contact is broken, another contact is made between 46 and 10, thereby preventing the banner from falling. The plunger cannot again be pulled out until the banner has been returned to the normal or "free" position. When the plunger completes its return stroke, the circuit from Y is as follows: From 101 through 1, 46, 10, block wire 22 to block wire 23 at X, 6, block indicator 80, 5, 48, locking up relay contact to 100. A shunt circuit is also provided from

48 through 49 and contact 2 on block lever roller to 100, the purpose of which is explained below. It should be remembered that the block wire numbered 22 at Y and 23 at X is a continuous wire. Indicator 80 clears when energized, showing X that Y has given an unlock; contact on the armature of 80 is also closed. To clear the block signal B at X after the unlock is given, the circuit is from 101 at X through 4, contact on indicator 80 (which is now closed), 7, 87, floor push (which must be closed), 82, block lever lock magnet, to 100. This

to the position "train in block" (catching on the bottom hook of latch 62). As the banner drops from the "locked" position, the contact below coil 46 opens, and energy from wire 101, which was connected to wire 22 through this part of the instrument, is now cut off.

As the train approaches Y, the signal H at Y cannot be cleared unless signal B is blocked and the track sections between signals H and B are unoccupied. This is provided for by the home lever lock which cannot be released to clear

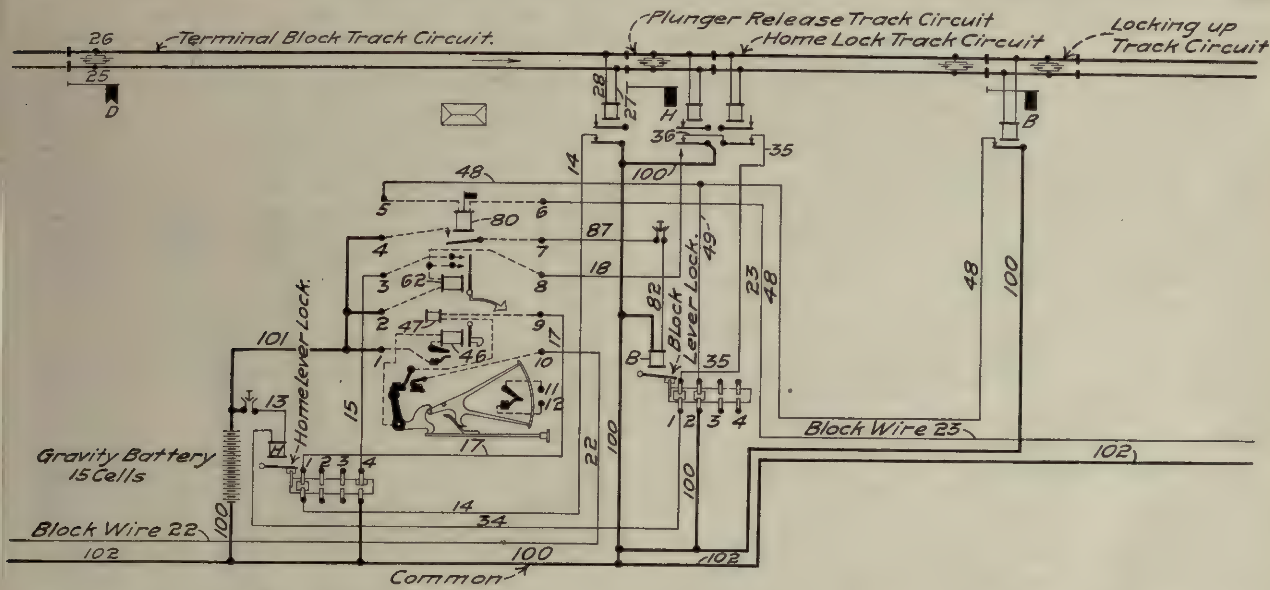


Fig. 352. Standard Circuit Plan for One Tower, Controlled Manual Signals, with Non-Continuous Track Circuit. New York Central & Hudson River.
The plans at Towers "X" and "Y" Referred to in the Description are Identical.

energizes the block lever lock magnet and unlocks the lever so that the signal B can be cleared. As soon as X clears signal B to permit train to proceed to Y, one shunt of the unlock circuit is broken at 2 on block lever roller between 49 and 100. The original circuit for the unlock, however, is still retained from 48 through locking up relay contact at signal B to 100. When the train enters the locking up track circuit beyond

the home signal H except through the circuit 101, floor push (which must be closed), 13, home lever lock, 34, contact 1 on block lever roller, 35, home lock relay contact, 36, plunger release relay contact to 100. After the home signal H has been cleared and the train enters the plunger-release track circuit, current flows from 101 through 2, 62, 8, 18, back contact on plunger-release relay to 100. This energizes 62 and lifts

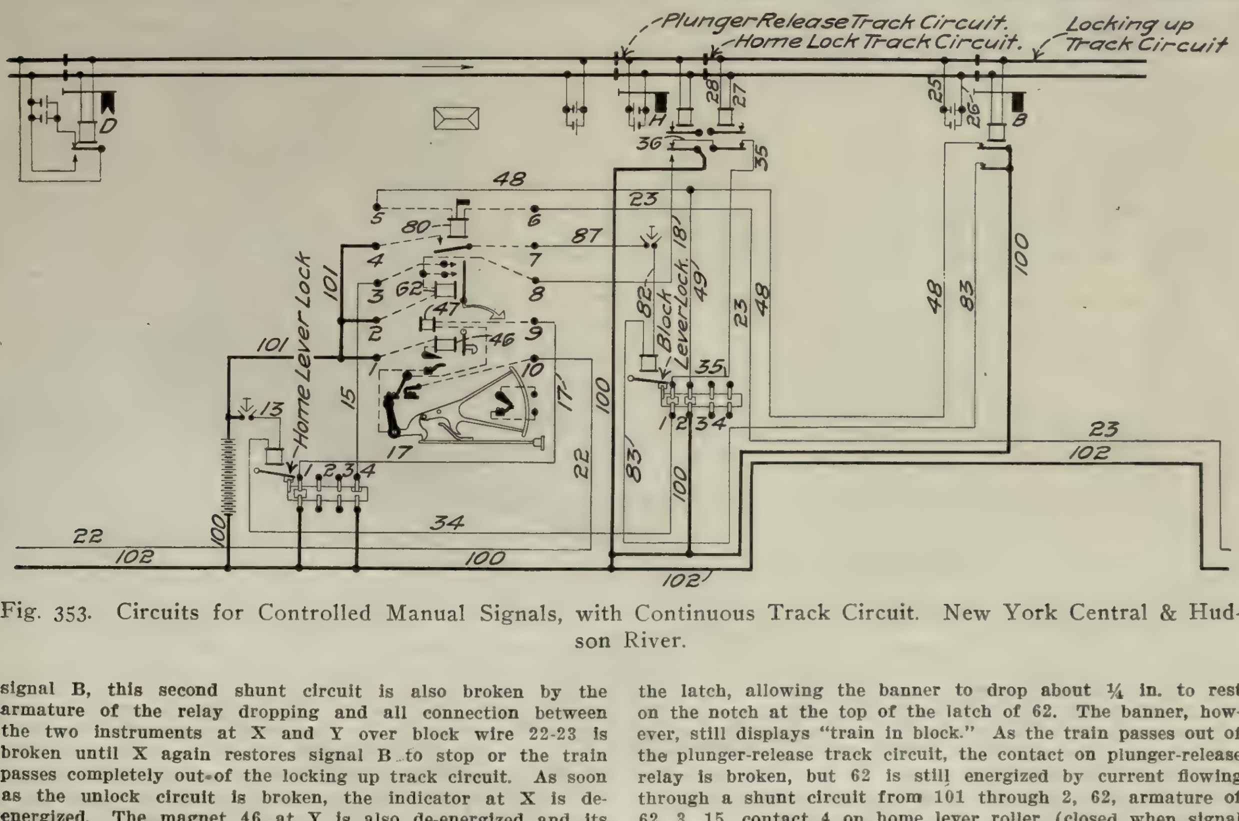


Fig. 353. Circuits for Controlled Manual Signals, with Continuous Track Circuit. New York Central & Hudson River.

signal B, this second shunt circuit is also broken by the armature of the relay dropping and all connection between the two instruments at X and Y over block wire 22-23 is broken until X again restores signal B to stop or the train passes completely out of the locking up track circuit. As soon as the unlock circuit is broken, the indicator at X is de-energized. The magnet 46 at Y is also de-energized and its latch armature swings away, allowing the banner to drop

the latch, allowing the banner to drop about ¼ in. to rest on the notch at the top of the latch of 62. The banner, however, still displays "train in block." As the train passes out of the plunger-release track circuit, the contact on plunger-release relay is broken, but 62 is still energized by current flowing through a shunt circuit from 101 through 2, 62, armature of 62, 3, 15, contact 4 on home lever roller (closed when signal is cleared) to 100. This current holds up the latch of 62

("train in block" still displayed) until contact 4 is broken by returning the home signal H to stop behind the train. When the signalman has done this, the latch of 62 drops and releases the banner, which then falls to the "free" position. The banner in returning to the "free" position releases the latch holding in the plunger bar, and an unlock can then be given for forwarding another train from X to Y.

It will be seen that an unlock can be given by Y to X at any time, provided signals B at X and H at Y are blocked, and the track between them is unoccupied. An unlock once given may be held indefinitely until used. In practice, notice of the approach of a train is given some time before its arrival. X may clear home signal H at any time (the control of its block being the same as already explained for the corresponding signal at Y); before a train comes within sight of his distant signal X asks Y for an unlock, and, on receiving it, clears signal B. With both the home and block signals cleared, the distant signal can then be cleared and the approaching train sent forward without slackening speed. After the train has passed signal B at X no other train can follow toward Y until the instrument at Y has been restored to its normal position by the passage of the first train over the plunger-release track circuit at Y, and the home signal H at Y restored to the stop position.

It is essential in any installation of these "controlled manual" instruments, that the first home signal be semi-automatic in its operation, going to the stop position automatically as soon as a train has passed. If this arrangement is not made, the signalman at the entrance of the first block, having received an unlock from the next tower in advance, might leave his signals in the clear position; the second signalman could in turn do likewise and so on. Thus, continuous clear signals could be displayed throughout the entire installation, for any number of successive trains.

Where switches operated from the tower are installed between the home signal H and the block signal B, a switch box is usually arranged to shunt the home lock track circuit relay when the switch is open, and thus prevent the home lever lock from being energized, as already explained. This is a precaution in addition to the mechanical locking between the switch lever and the home signal lever in the tower, and is valuable in case the mechanical connections to the switch should become disconnected while the switch was open, thus allowing the switch lever to be returned to normal, and the home signal cleared, while the switch remained open. For arrangement of circuits with non-interlocked outlying switches, see Figs. 359-360.

The controlled manual system described in connection with

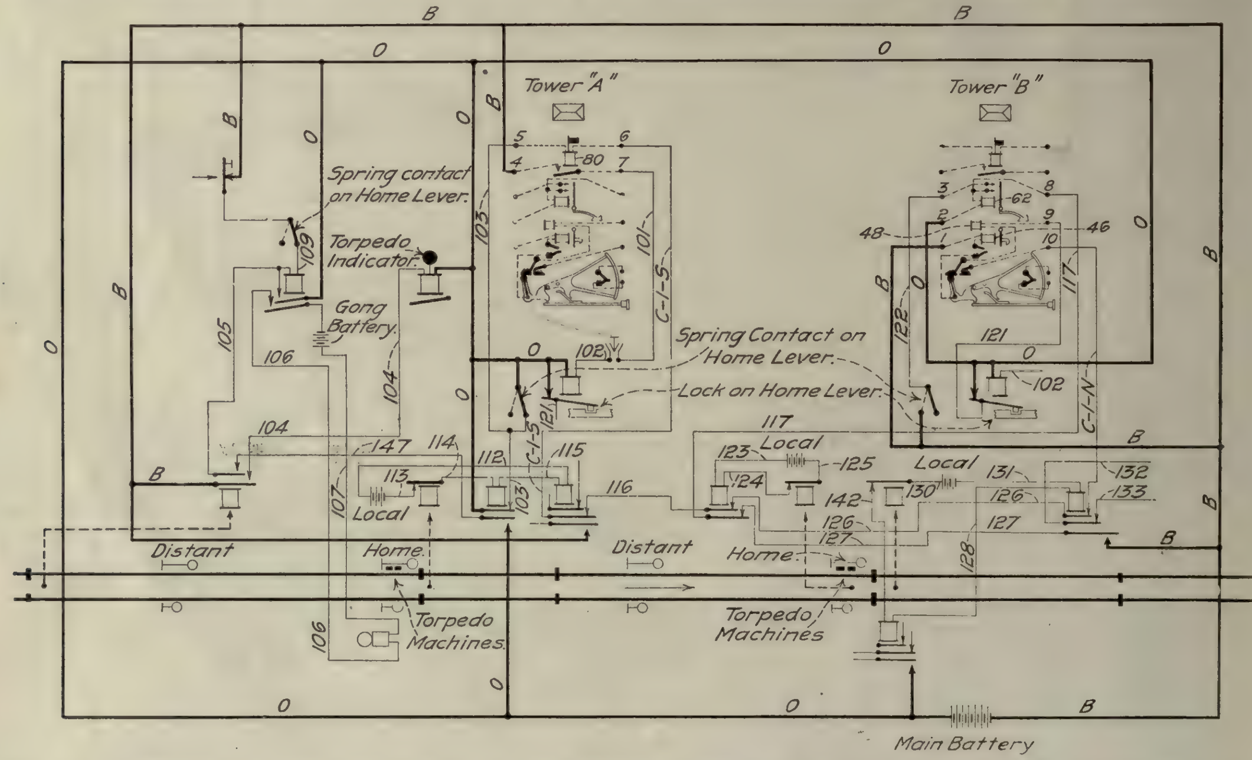


Fig. 354. Circuits for Controlled Signals in Park Avenue Tunnel of the New York Central, New York City; Continuous Track Circuit, Overlaps, Torpedo Machines and Alarm Gongs, but no Advance Block Signals.

In case the signalman at Y attempts to give X an unlock while a train is in the terminal track circuit section, or while his home signal is clear, the magnet 46 is de-enerzided and its latch will not hold up the banner, which drops to "train in block" when the plunger is released. The signalman may then repeat the operation of plunging to give X an unlock any number of times, but until magnet 46 is energized and holds the banner in the "locked" position no current can flow from Y to X to unlock X.

The floor pushes are for the purpose of economy in the use of battery.

The purpose of coil 47 is to introduce dead resistance in series with coil 46, while on local circuit, corresponding to the resistance of the block wire 22-23 and the indicator 80 at the next tower. Its use prevents excessive current from flowing through coil 46, which would tend to produce residual magnetism in that coil, and it also increases the efficiency of the main battery for use on other circuits.

The unlock shunt, wire 49, may be, and sometimes is, omitted. Its purpose is to provide a means of operating the instruments in case of failure of the locking up track circuit. It will be seen that if the circuit through 48 and locking-up relay contact to 100 is broken (by failure of the relay or track circuit to operate properly) the unlock can still be given when necessary and is taken away every time the block signal B is cleared to permit a train to proceed toward the next tower.

Fig. 352 provides complete protection against every possibility of collision between trains, except in case of a train breaking in two between X and Y, leaving one or more cars in the block. The signalman at Y, unless he carefully observes the rear-end train markers, may give an unlock to X after part of a train has passed out of the block, while the rear cars are standing somewhere between the towers. In order to give protection against this possible danger a continuous track circuit may be employed between signal B at X and signal H at Y. Such an arrangement is shown in Fig. 353. In effect, the locking-up track circuit at X is extended through the block and is relayed through the terminal block track circuit at Y. An additional contact is added to the track relay of the locking-up track circuit at signal B and the circuit which unlocks the block lever is carried through it as follows: From battery wire 101 to binding post 4, contact on armature of indicator 80, binding post 7, wire 87, floor push (which must be closed), wire 82, block lever lock magnet, wire 83, front contact on locking-up track circuit relay, to common wire 100. The block lever lock cannot be released to clear signal B as long as the track section between signal B at X and signal H at Y is occupied. Protection is also afforded against broken rails, since a break would de-energize the locking-up relay and open the contact in the unlocking circuit, thereby preventing signal B from being cleared. The only other difference between the other circuits shown in Fig. 353 and those shown in Fig

352 is that the preliminary circuit, required before an unlock can be given, is carried direct to common wire 100 from contact 1 on home signal lever roller instead of through contact on terminal block relay.

The shunt circuit for the unlock through wire 49 and contact 2 on the block signal lever roller to common wire 100 is retained, but for a different purpose from what was explained in connection with Fig. 352. It is needed here in case a train has to pass signal B for switching purposes. If the signalman had obtained an unlock and should allow a train to pass signal B, without wire 49, he would lose his unlock as soon as the train entered the locking-up track circuit. But by keeping signal B blocked and giving the train permission to pass it in that position (for switching purposes only), he saves his unlock to use when they are ready to depart, and thus avoids issuing a caution card which would otherwise be necessary in order to permit them to proceed.

Fig. 355. Two-Lever Dwarf Interlocking Machine with Electric Locks, Controlled from a Block Station.

The object in putting in a cut section at the distant signal D and relaying the locking-up track circuit through it to signal H is to simplify the connections in case it is desired to put in an outlying switch between signals D and H, or to make D a semi-automatic signal.

In Fig. 354 the plunger-release track circuit and the locking-up track circuit are combined, as stated on page 28, and lengthened to form an overlap section in advance of the home signal. In this explanation, the relay controlled by the track circuit of this overlap section will be termed the overlap relay, and the relay in the track circuit extending from the home signal back to the next overlap section in rear will be termed the terminal block relay. For tower B to give tower A an unlock, the preliminary circuit is from battery to b. p. 1, through instrument to b. p. 9, wire 121, back contact on home lever lock to common wire O. The home signal must, therefore, be locked in the stop position. The unlocking circuit is from battery to b. p. 1, through instrument to b. p. 10, wire C-1-N, front contact on relay, wire 126, front contact on relay, wire 116, front contact on relay, wire C-1-S to b. p. 6 at A, through block indicator 80 to b. p. 5, wire 103, front contact on relay to common wire O; or from wire 103 through spring contact on home lever, normally closed, to common wire O. The first relay in this circuit is energized by local battery through front contact on overlap relay; the overlap section must be unoccupied and overlap relay energized in order to make contact on local relay. The second relay in the circuit is energized by local battery through front contact on terminal block relay. The third relay is similarly energized through front contact on overlap relay at A, and the last relay between wire 103 and common is also energized through front contact on overlap relay at A. The overlap section at B and the entire track section between home signals at A and B must be unoccupied in order to give an unlock. When unlock has been received at A, the circuit is from battery to b. p. 4, contact on indicator 80, b. p. 7, wire 101, floor push (which must be closed), wire 102, home lever lock magnet to common wire O. The home signal at A can be cleared as soon as the home lever lock magnet is energized. As soon as the train enters the overlap section beyond the home signal at A, the overlap relay is de-energized and the unlock circuit is broken by the relay between wire 103 and common. This locks the instrument at B in "Train in Block" position. In case the relay between wire 103 and common does not act properly, contact is broken on the unlock circuit by the spring contact on home lever at A, which is opened when home signal at A is cleared. As soon as the train has cleared the overlap section at B,

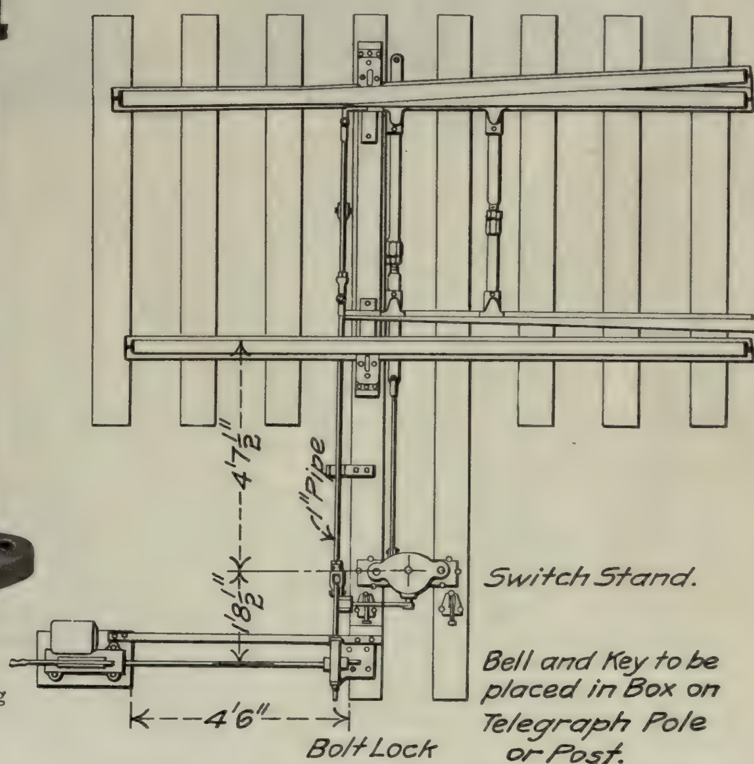


Fig. 356. Hand Switch, Bolt Locked by Dwarf Machine, New York Central & Hudson River.

all relays are again energized, the block instrument at B returns to normal and another unlock may be given.

Torpedo machines are installed at the home signals and are operated with the home signal lever. In order to warn the operator at A not to block the home signal and put torpedoes on the track before the train has passed entirely beyond the home signal a contact is added to the terminal block relay in rear of home signal at A, and current flows from battery through back contact on this relay, wire 104, and through a torpedo indicator to common wire O. This indicator is energized until every pair of wheels in the train has passed into the overlap section beyond the home signal and torpedo machine. The operator does not return the home lever to stop until the torpedo indicator clears.

If for any reason a train runs by the home signal at A in the stop position a loud gong begins to ring. As soon as the first pair of wheels enters the overlap section, while the rear wheels are still in the terminal block section in rear of the home signal, both the terminal block relay and the overlap relay are de-energized. This closes the circuit from battery through spring bell key closed, through spring contact on home lever (closed when signal is in stop position), wire 109, stick relay, wire 105, back contact on terminal block relay, wire 147, back contact on relay to common. The stick relay

he reverses this roller, contact 2 is opened, breaking connection between wire 167 and 100, and de-energizing magnet S, which then locks the controller in its reversed position. The train may now use the switch, and, if necessary, may clear the main track entirely to allow one or more trains to pass. In case it is desired to do this, the trainman, after closing the switch and locking it for the main track, restores the switch lock to its normal position, closing contact 2 on its roller. This again completes the circuit through magnet S (as already described), and the controller may then be returned to its normal position by the signalman. He must do this before he can clear signal H, because, as already stated, the circuit for lever lock H is carried through contact 1 on the switch lock controller and is closed in its normal position only. When he reverses signal H to allow a train on the main track to pass over the switch, he breaks the connection between wire 90 and wire 163, locking controller S normal.

Having received an unlock from the next tower in advance, as already described, he then clears signal B and allows the main line train to proceed. After it has passed, he must restore signal B to the stop position before he can unlock the outlying switch, because the circuit for magnet S is carried through a normal contact (3) on the block lever roller. This arrangement prevents him from permitting the train,

Fig. 357. Electric Lock with Semaphore Indicator. The Union Switch & Signal Co.

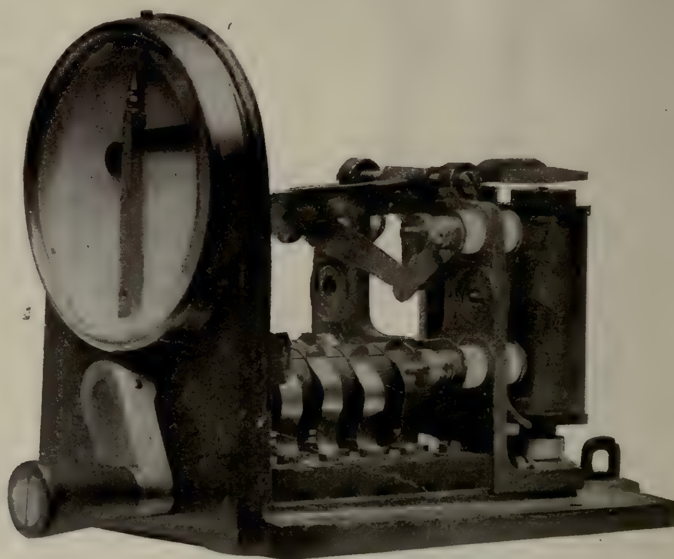


Fig. 358. Electric Lock Shown in Fig. 357. Cover Removed.

is energized and current flows from gong battery through wire 107, gong wire 106, front contact on stick relay to battery. The gong continues to ring until the operator at A opens the spring key and allows the stick relay to drop.

Figs. 355-360 show the method used in controlling main line switches which are situated too far away from towers to be interlocked. Such switches are operated by hand and are known as outlying switches. They are electrically locked and controlled by the signalman in an adjacent tower. The arrangement shown in Fig. 355 would cover two separate switches, one lever and one lock for each. The lever mechanically bolt-locks the switch in its normal position and is in turn interlocked with the roller and segment of the electric lock. A switch lock controller, Figs. 357 and 358 is placed in the tower and connected, as shown in the wiring diagrams. Communication by bell code and telephone is also provided.

Fig. 359 shows the arrangement for an outlying switch between the home and advance signals and may be used with either continuous or non-continuous track circuits. The controller in the tower is locked in either normal or reverse position when its magnet, S, is de-energized. To permit a train standing between the switch and signal B to use the switch, the signalman closes the floor push from battery wire 101 to wire 89, completing the circuit through coil S, wire 90, contact 3, on home lever roller, wire 163, contact 3, on block lever roller, wire 167, and contact 2, on switch lock roller to common return wire 100. This circuit, if complete, insures that both the home and advance signals are in the stop position, and also that the switch lock is normal. The signalman then reverses his controller, opening contact 1, which locks the home signal lever normal, and closing contact 2, which completes the circuit from 101 through wire 164 and switch lock magnet to 100, unlocking the switch lock, which must be reversed by the trainman before he opens the switch. When

coming out of the siding, to follow the other into the block without getting another unlock, which might otherwise be done.

The controller may now be operated, the switch unlocked and used and the controller restored in the same manner as before.

An outlying switch between block signal at one tower and distant signal at tower in advance is locked and controlled by the signalman in the tower in rear, by means of the switch lock controller shown in Fig. 360. This controller is locked in either normal or reverse position when the magnet S is de-energized. The preliminary and unlock circuits are the same as already described, except that wire 49 is continued through roller on block lever to roller contact 5 on the switch lock controller, and thence to common return wire 100; a relay, K, is also introduced, controlled through wires 87 and 81, by indicator 80. A train having passed the signal B, and wishing to use the outlying switch on arrival, stops and stands on the lock-releasing track circuit. Communication is established by bell key and telephone with the tower in the rear, and an unlock for the switch is asked for. The circuit for unlocking the switch controller at the tower is as follows: From battery wire 101, through lock magnet S, wire 89, floor push, wire 90, contact 1 on switch lock controller, wire 85, contact 4 on block lever roller, wire 86, of switch lock L (now closed), wire 58 and roller contact to 100. The switch lock controller in the tower is then restored to its normal position, and by opening roller contacts 2 and 3 it locks itself and the switch lock L in the normal position. Any number of trains may now be sent through the block in the usual manner.

When the train in the siding wishes to again take the main track, it is necessary for the tower in advance to give an unlock to the tower in rear, all signals being in the stop position. This energizes the relay K through wire 81, making a front contact for wire 86 and permitting the switch lock

controller to be unlocked through the following circuit: Battery wire 101, lock magnet S, wire 89, floor push, wire 90, contact 1, wire 85, contact 4, wire 86, front contact (now closed) on relay K to common. The switch lock controller is then reversed, unlocking the switch lock roller. When the switch lock roller is reversed to unlock the switch, in order to allow wire 218, "stick" relay N, wire 73, contact on switch lock roller to common. This permits the banner in the instrument at the advance block station, which now shows "train in block," to drop to the second latch of that position. The relay N will remain energized if a car is allowed to remain standing on the track anywhere between signal B and signal H through a

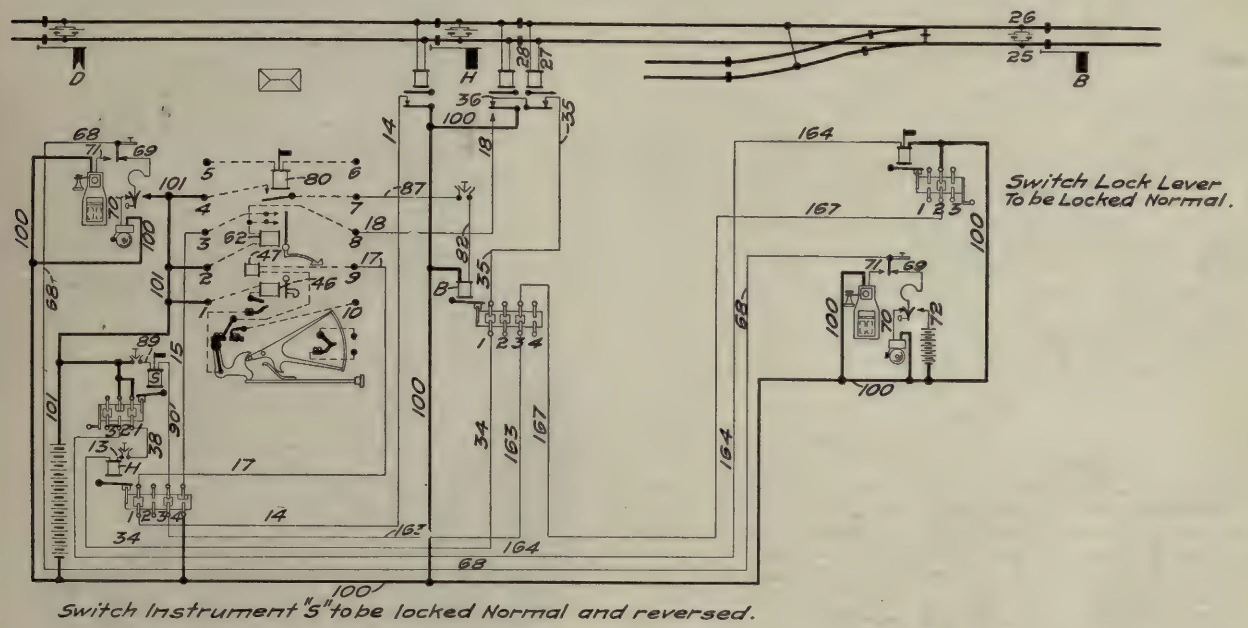


Fig. 359. Circuits for Controlled Manual Block Signals, with Non-Continuous Track Circuits and Outlying Switch Between Home and Advance Signals. New York Central & Hudson River.

the train to take the main line, a local indicator circuit is made up as follows: From 2-cell "SS" battery through back contact on relay K, wire 67, back contact (now closed) on lock-releasing circuit relay, wire 58, contact on switch lock roller to 100. This unlocks the switch lock controller in the tower, which is then reversed, opening contacts 1, 4 and 5 and closing contacts 2 and 3; opening contact 4 locks signal B in the stop position. Current then flows from wire 101, through contact 3 on switch lock controller, wire 64 to switch lock magnet L to 100. This unlocks the switch lock roller, "stick" connection with back contacts on the relays controlled by this section of track (wires 75 and 76). If the train entirely clears the main line in taking the siding, the switch is thrown and then locked in the normal position by restoring the switch lock roller to normal, the contact of wire 73 is again broken and if the signal H' is in the stop position the banner at the tower in advance drops to the "free" position. Roller contact between wires 58 and 100 (which was broken) is now closed and the switch lock controller magnet S is energized through circuit as follows: From 101, through coil S,

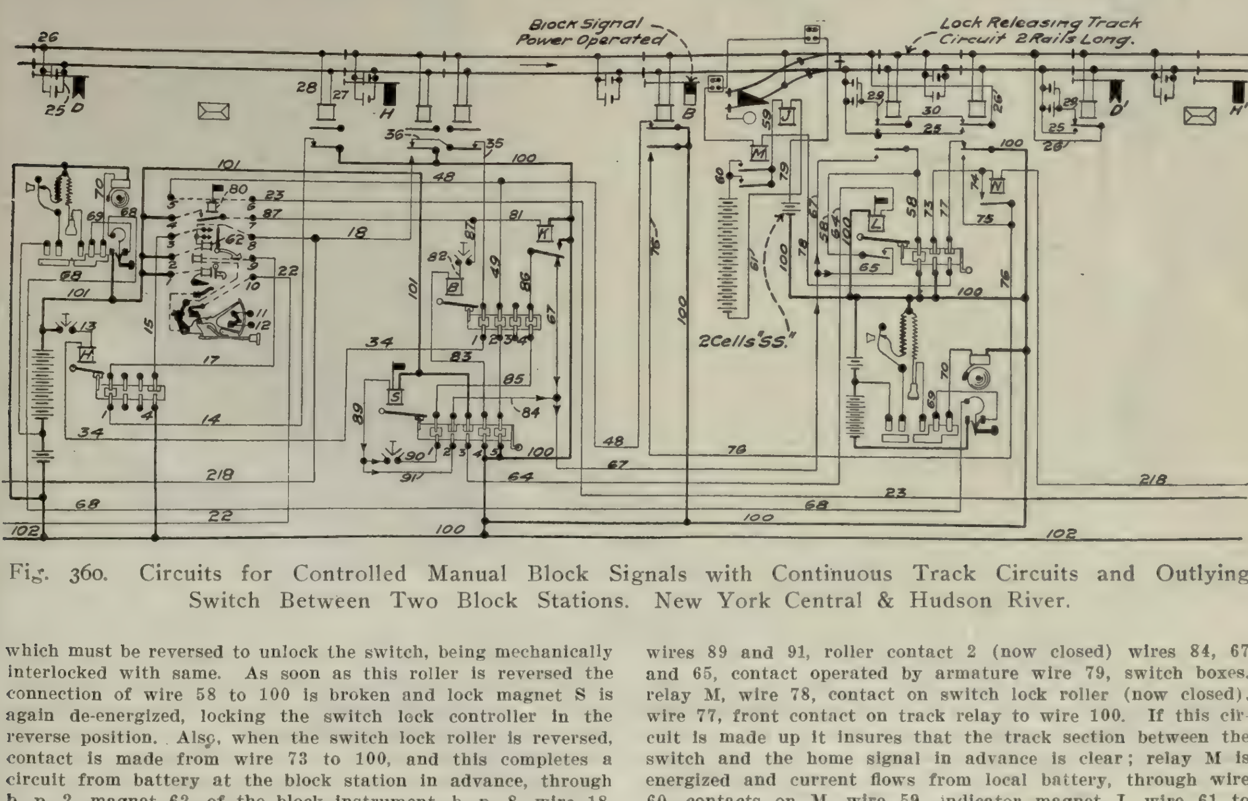


Fig. 360. Circuits for Controlled Manual Block Signals with Continuous Track Circuits and Outlying Switch Between Two Block Stations. New York Central & Hudson River.

which must be reversed to unlock the switch, being mechanically interlocked with same. As soon as this roller is reversed the connection of wire 58 to 100 is broken and lock magnet S is again de-energized, locking the switch lock controller in the reverse position. Also, when the switch lock roller is reversed, contact is made from wire 73 to 100, and this completes a circuit from battery at the block station in advance, through b. p. 2, magnet 62, of the block instrument, b. p. 8, wire 18, wires 89 and 91, roller contact 2 (now closed) wires 84, 67 and 65, contact operated by armature wire 79, switch boxes, relay M, wire 78, contact on switch lock roller (now closed), wire 77, front contact on track relay to wire 100. If this circuit is made up it insures that the track section between the switch and the home signal in advance is clear; relay M is energized and current flows from local battery, through wire 60, contacts on M, wire 59, indicator magnet J, wire 61 to

battery. This indicator when energized shows "clear" and permits the train to leave the siding. After the train is again on the main line the switch is returned to normal and locked by the switch lock roller being restored to normal position, and controller S is unlocked and restored as already described. It is also necessary that the block instrument at the tower in advance be allowed to drop to the position "train in block." This is done by a combination of two circuits which drops the banner from "locked" past the first notch of the "train in block" position to the second notch, as follows: Reversing the switch lock controller at the tower in the rear cuts the circuit of wire 49. As soon as the train passes the fouling point in going out of the switch it de-energizes the locking-up relay at B, thus cutting wire 48. But before this occurs, contact is made in reversed position of the switch lock roller for wire 73, thus causing current to flow from battery at tower in advance, through block instrument wire 218, stick relay N, wire 73 to common. As soon as the train enters the fouling section the banner drops from the "locked" position to the "train in block" position, but the circuit made up through 218 has energized magnet 62 and permits it to pass the first notch, catching it on the second. As soon as the train passes the home signal H' at the tower in advance, the plunger release track circuit and the home signal lever at that point restore the instrument to its normal position in the usual manner.

G. R. S. CONTROLLED MANUAL SYSTEM.

In Fig. 368 A, B and C represent block stations on a single-track road, with train movement to be made from A in the direction of C. In order to display "proceed" signal at A, it is first necessary for operator at A to request release or unlock from operator at B. If the block is unoccupied, the opposing signal at B in the stop position and other conditions favorable, operator at B closes circuit controller on his instrument by means of lever 12 connected thereto. This action must be simultaneous with the action of the operator at A, who closes similar controller on instrument at that point through lever 13. This joint action closes the unlocking circuit and current flows from battery at B through wire 1 (Fig. 369), back contacts on electric locks 2-2, contact 3, wire 5, safety contact 6, wire 8, indicator 1 at A, wire 9, contacts 10, wire 11, coils of electric lock L at A, to ground or common. Indicator coils at A and B and lock coil at A are then energized, indicators showing unlocking circuit closed. Lock coil at A now attracts armature, releasing lock 14 and permitting the withdrawal by the signalman of plunger 15, which being connected to lock lever 17, releases cam crank 21 and permits the clearing of signal. The mechanical operation is effected by operator turning crank 16 a half revolution. This crank is directly connected to the shaft on which ratchet wheel 18 is mounted.

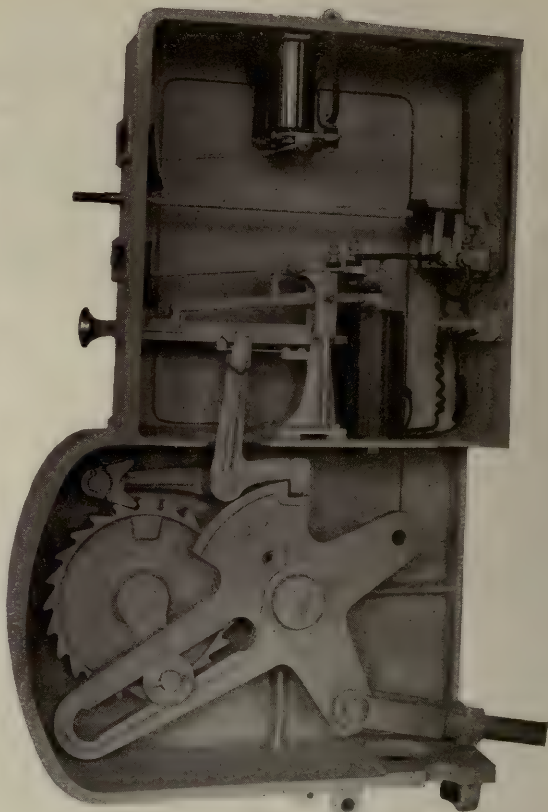
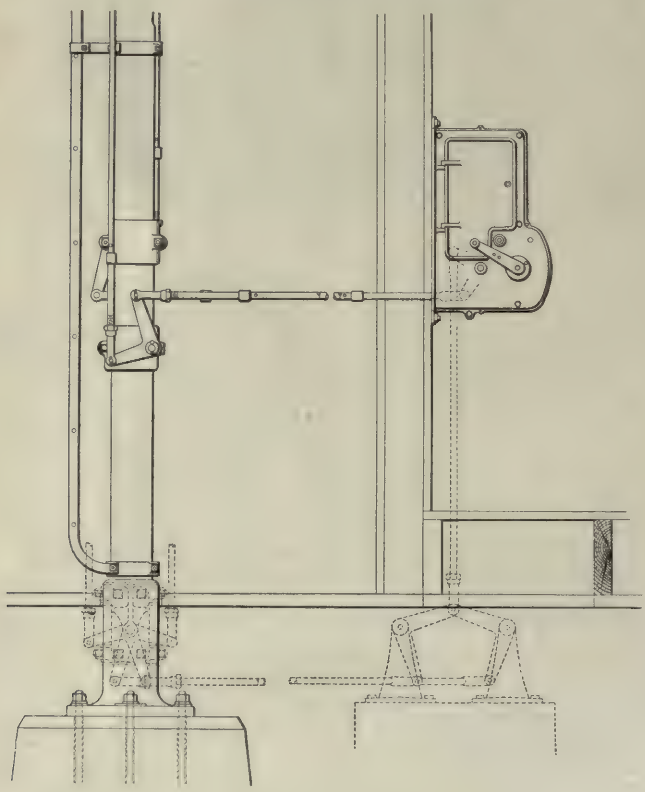


Fig. 361. Section Through Block Instrument. General Railway Signal Company.



Figs. 362-363. Pipe Lead-out Connection from Block Instrument to Signal. General Railway Signal Company.

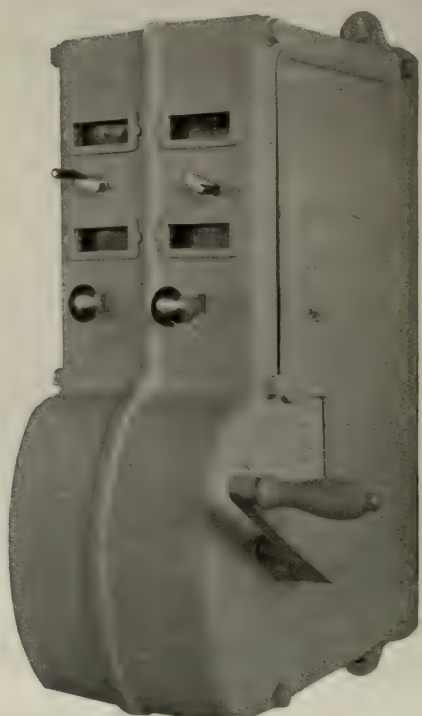


Fig. 364. Double Block Instrument for Single Track.

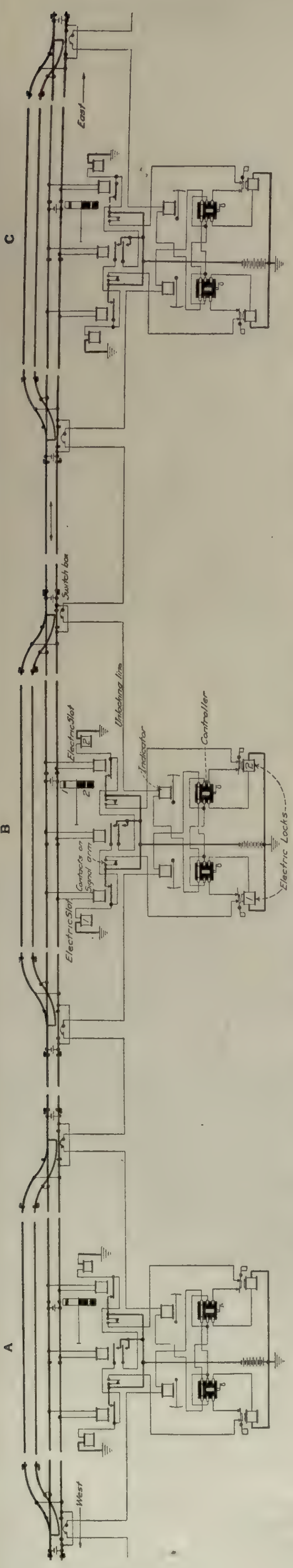


Fig. 365. Typical Circuit for Single Track; Non-continuous Track Circuits; Semi-automatic Signals.

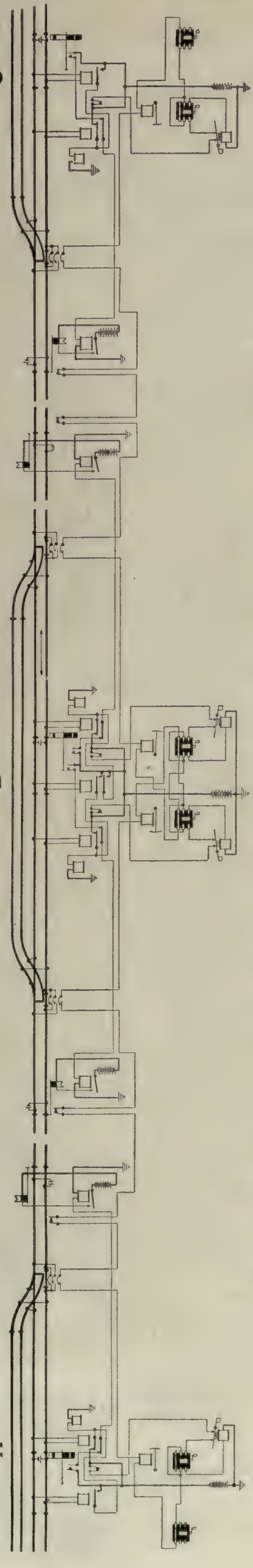


Fig. 366. Typical Circuit for Single Track. Similar to Fig. 365, with Addition of Power-operated Distant Signals and Contacts in Switch Boxes for Control of Track Circuits.

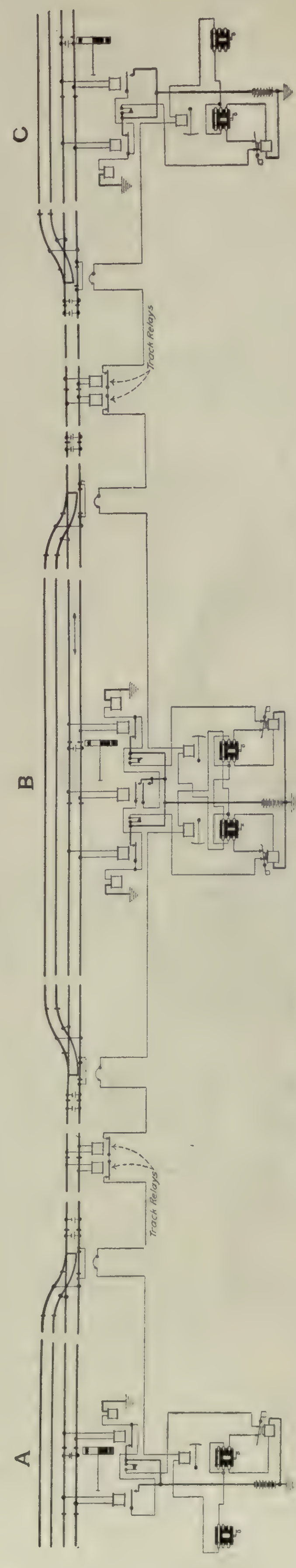
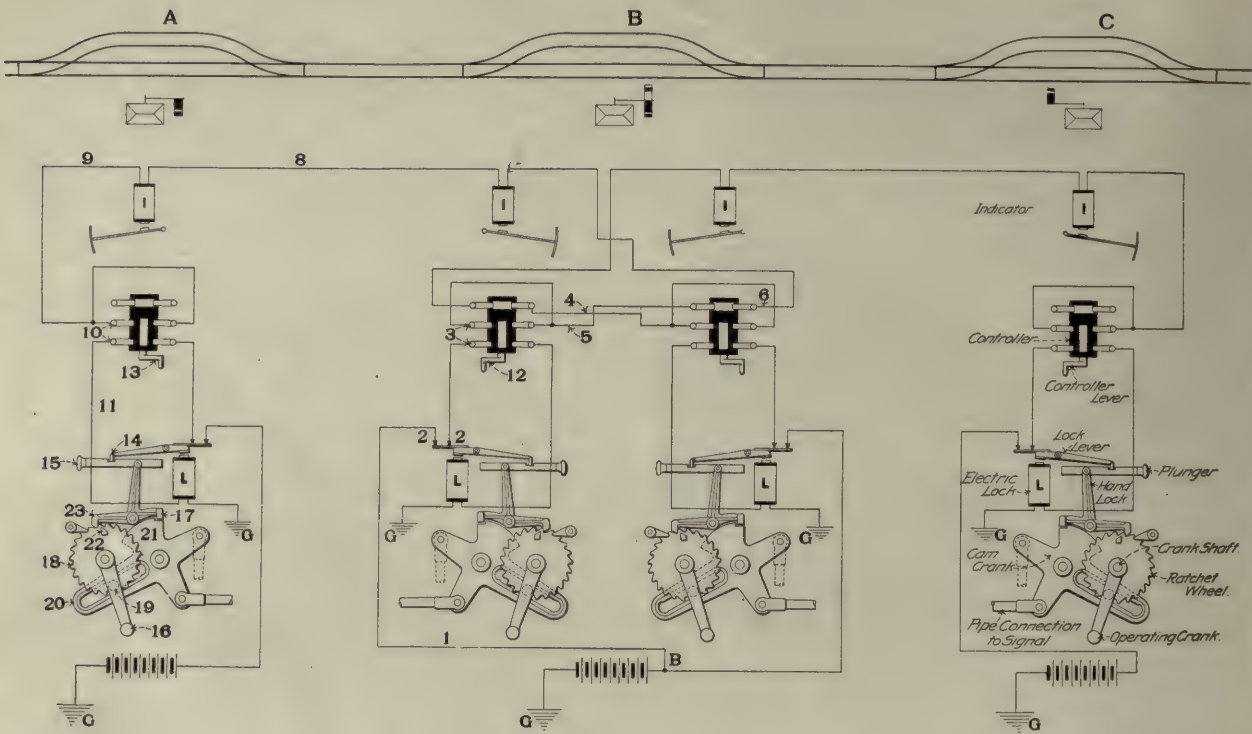


Fig. 367. Typical Circuit for Single Track; Continuous Track Circuits.

the latter having a stud, 19, engaging slot 20 in cam crank 21. Thus the rotary movement of the mechanism is converted into linear movement at the pipe connection to clear the signal. The machine is connected as in Figs. 362-363.

After train has entered the block, the signalman completes the revolution of crank 16, thus placing signal in stop position and completing the movement. To prevent crank 16 from being turned except in the proper direction, ratchet wheel 18 is engaged by a pawl, thus insuring proper operation of the crank. On this ratchet wheel a stud or boss, 22, is fixed in such a manner that when the crank, 16, is restored almost to normal position it engages arm 23 of lock lever 17, forcing same home and preventing further operation until another release or unlock is received.

Continuous track circuit without distant signals is shown in Fig. 367. In Fig. 370 a complete development of the system is illustrated; the arrangement showing block, home, distant and train order signals, continuous track circuit, indicators and electric locks at switches all under the control of operator at adjacent block station. No movement may be made from sidings to foul the main track without the permission and co-operation of the block operator at the adjacent station and the operator at the far end of the block, the same co-operation being required as for a main track movement.



Figs. 368-369. Diagram of Circuits and Instruments for Typical Installation of Controlled Manual System for Single Track. General Railway Signal Company.

CONTROLLED MANUAL ON PENNSYLVANIA.

Figs. 371-373 show the circuits used for a Single Track Controlled Manual Block System on the Pennsylvania Railroad between Cameron, Pa., and Sterling Run. This system provides protection against butting collisions, but is permissive for following movements. Electric approach locking is provided at both plants.

At each station there is a block instrument for each block (1-G, 2-G); there is also a signal-controlling instrument (1-F, 2-F). These instruments are similar to those shown in Figs. 357-358. There is also at each station in addition to the ordinary indicators an indicator (1-C, 2-C) which shows whether or not the track is occupied for a distance of 1,000 ft. beyond

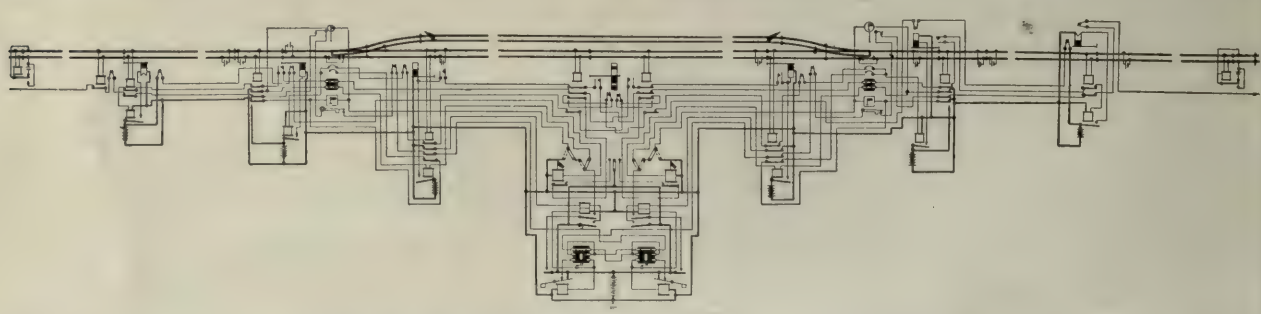


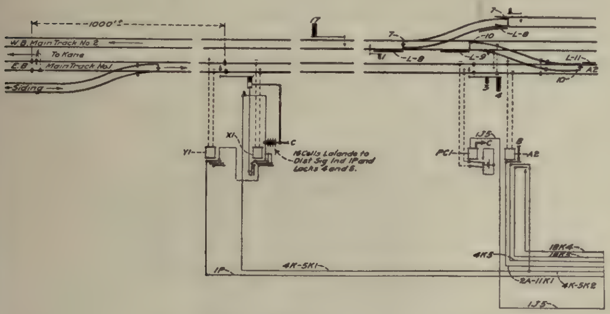
Fig. 370. Arrangement of Circuits for Complete Development of System, Showing Power-operated Home and Distant Block Signals, Train-order Signals, Indicator and Electric Locks at Switches, and Continuous Track Circuits. General Railway Signal Company.

Fig. 365 shows the system as illustrated in Fig. 369 with the addition of semi-automatic or slotted signals. The signals remain clear until the entire train has passed them, the signals returning to stop automatically immediately after the rear end has cleared. Power operated distant signals may be provided and operated in conjunction with the block instrument, as shown in Fig. 366. These signals indicate caution at all times, except when the block signal is clear, switches set for the main track and section between the distant and block signals is unoccupied.

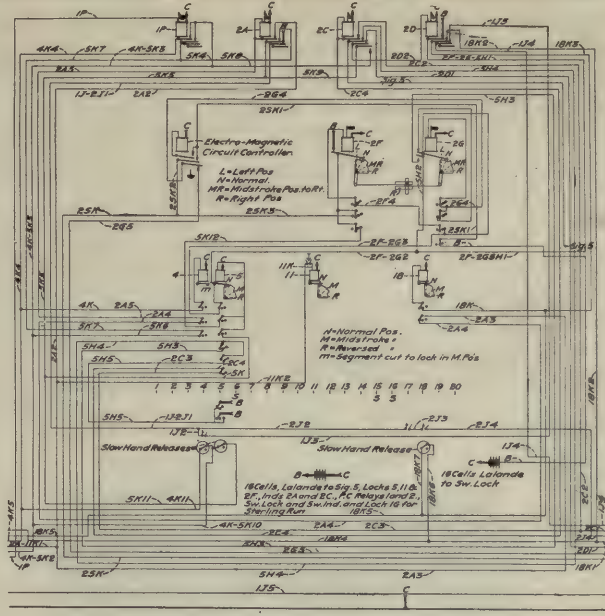
the advance signal; and an indicator (1-D, 2-D) which shows whether or not the track is occupied between the advance signal and a point several hundred feet beyond the outlying switch. Switch indicators are placed at such switches in addition to the switch locks to indicate to a train on the siding whether or not it has permission to proceed on to the main line.

To move a train from Cameron (Fig. 371) to Sterling Run (Fig. 373) the procedure is as follows: Operator at Cameron asks operator at Sterling Run for an unlock. This is given by moving the handle of controller 1-G (see Fig. 373) at Sterling Run to the left. This closes a circuit from B, front contact on relay 1DZ at Sterling Run through wires 1F-1G-13H1. 1F-1G2, contact on electric lock 13, controller on same lock, wire 1F-1G3, upper contact on controller 1G, middle circuit breaker of same controller. wire 1G4, contact of relay S1, wire 1G5, contact on switch lock, 1SK, wire 1G6, contacts on relays T1, T2, wire 2G7, contact of relay S2 at Cameron, contact of switch lock 2SK, wire 2G5, back contact of electro-magnetic circuit controller at Cameron, wire 2G4, circuit controller on 2G, coils of 2G to common. This energizes 2G and releases its handle for a movement to the right. The operator at Cameron moves handle of 2G to the right. This releases handle 2F through the tappet locking at R and closes a circuit from B at indicator 2D, through a point of 2D, wire 2F-2G-5H1, wire 2F-2G2, contact on lock 5, circuit controller on lock 5, wire 2F-2G3, circuit breaker on 2G, wire 2F4, circuit controller on 2F, coils 2F to common. This energizes 2F and releases its handle. The operator moves the handle of 2F to the right. This releases the lever of signal 5 and the signal can be cleared.

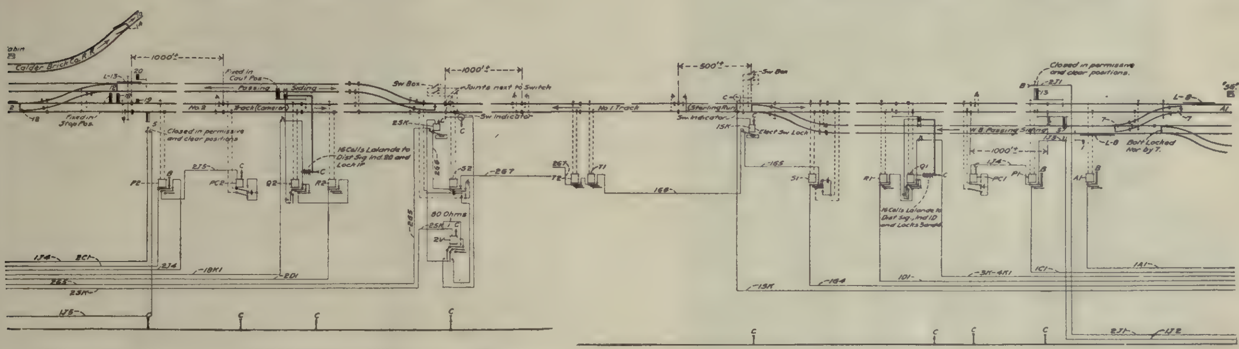
The signal is put to the stop position behind the train by the slot. The slot circuit is controlled by indicators 2C and 2D when 2G is energized. When 2G is de-energized, as when a train is anywhere between stations, it is controlled by 2C only. The arrangement of contacts on lever 5, where slot 5 gets current from B, is such that the slot can be kept energized with a train beyond the control of indicator 2C if the lever is not pulled beyond the middle position (see wire



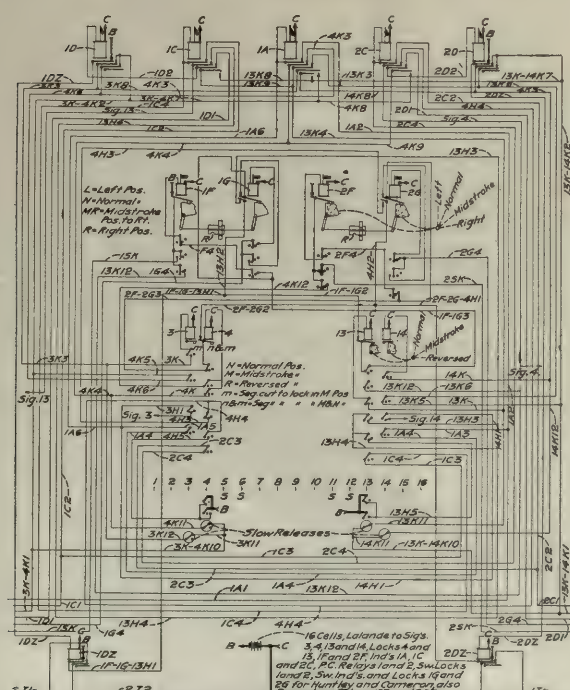
Track Section West of Cameron.



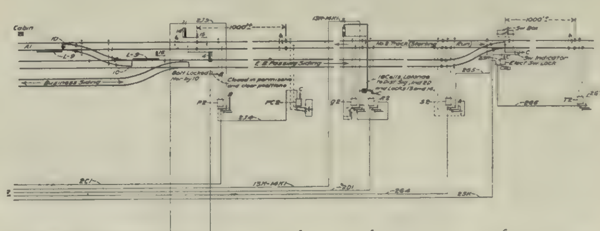
Wiring in Cabin at Cameron.



Track Section Between Cameron and Sterling Run.



Wiring in Cabin at Sterling Run.



Track Section East of Sterling Run.

Figs. 371-373. Circuits for Single Track Controlled Manual Block Signals. Pennsylvania Railroad.

5H5 and two lower contacts on lever 5). This indication is given for permissive signaling.

Provision is also made for letting a train out of a siding at a switch in the block after any and all trains admitted to the block have passed the switch. It is not necessary to wait for the block to be actually cleared by a train moving in the facing direction. A train can be let out of a siding after the passage of a train in the trailing direction, but not while such train is moving from the block station to the siding switch (see switch lock circuits SK).

THE ELECTRIC TRAIN STAFF SYSTEM.

Figs. 374-380 show the electric train staff instrument made by the Union Switch & Signal Co. for use on single track lines. One instrument is installed at each end of the block; that is, in a continuous installation, two at each block station. Fig. 381 shows the wiring diagram for two staff block stations. To move a train from X to Y the manipulation of the instruments is as follows: The operator at X presses bell key, A, the number of times prescribed in the bell code, which rings the bell at Y, through the circuit 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17. The operator at Y first acknowledges receipt on his bell key by ringing the bell, L, at X (through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23, 24, 25, 17, 16, 15, 14, 13, 26), and then holds it closed, thereby deflecting the "current indicating needle," 43, Fig. 379, at X to the right. This informs X that Y has furnished X current and he proceeds to remove the staff by turning the preliminary handle, 45, Fig. 379, to the right as far as it will go, which raises the armature up to the magnet K, transferring the current from bell L to the coil K88, through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23, 27, 28, 25, 17, 16, 15, 14, 13, 26, and at the same time closing the circuit on coil K360 through the circuit, 1, 2, 29, 30, 28, 25, after which the preliminary spindle handle is permitted automatically to return to its normal position. This unlocks the revolving drum, 8, Fig. 377, and indicates the fact by displaying a white instead of a red disk in the indicator, 44, Fig. 379. The operator now moves the end staff up the vertical slot into engagement with the drum (the outer guard having first been turned to the right position) revolving the latter through half a turn, using the staff as a handle, and finally withdraws the staff through the opening at 48, Fig. 379. In making the half turn, the drum has reversed the polarity of the operating current, thereby throwing the instruments at X and Y out of synchronism with each other and moving the "staff indicating needle," 42, Fig. 379,

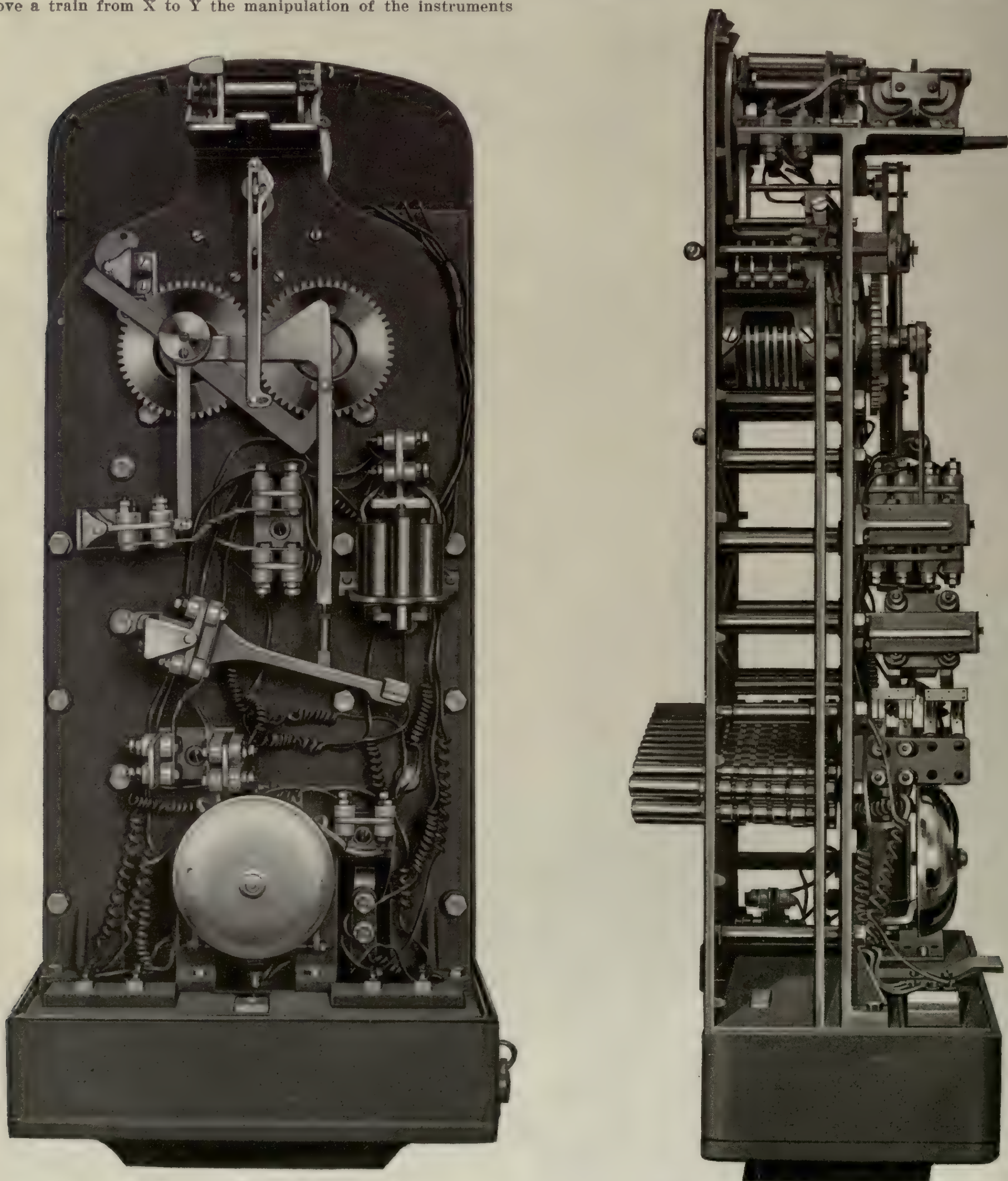
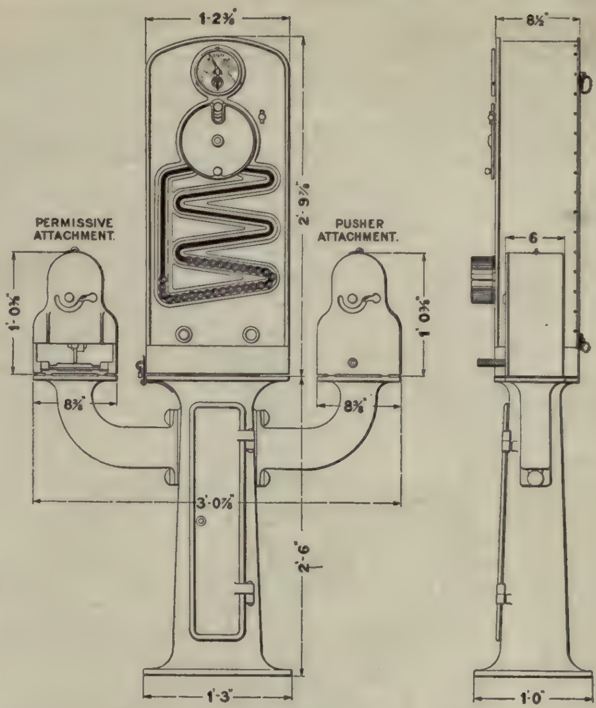


Fig. 374. Electric Train Staff Instrument. The Union Switch & Signal Co.

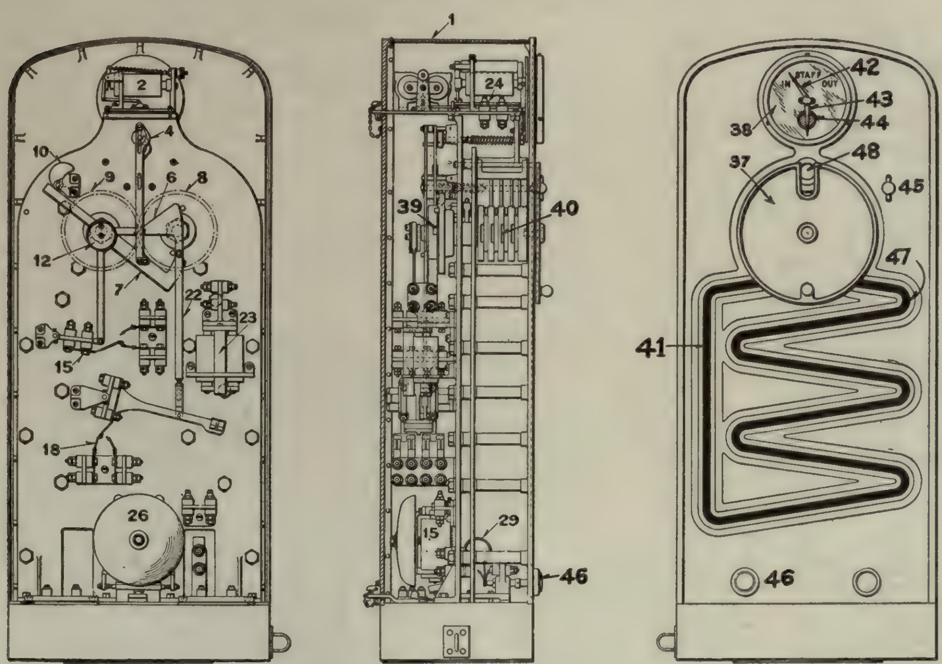
from "staff in" to "staff out." Immediately on withdrawing the staff, the operator at X once more presses his bell key, A, which indicates to the operator at Y, by moving his needle from "staff in" to "staff out" that the operation is completed.

The staff is now delivered to the train. The magnet K has two separate coils, one energized by the local and one by the line battery. The construction of this magnet is such that when the currents in both coils flow in the same direction the lines of force pass around the cores and connecting straps, thus forming no point of attraction for the armature. When the current is reversed in one coil the lines oppose each other and the armature being brought to the point of attraction, is held there. The polarity of the local current going through the magnet, K360, Fig. 381 is never changed. The polarity of the current flowing through K88, Fig. 381, is changed every time the staff is put in or taken out of either instrument. This puts the instruments either in or out of synchronism. With the staff out, the circuits are as follows: From the positive side of the battery at Y, through 19, 20, 21, bell key, A, closed, 8, 7, 6, 5, 17, 25, 24, 23, 22, 4, 16, 15, 14, 13, 26, to the negative side of the battery at Y. If an attempt should be made to release a staff by turning the preliminary handle, the operating current would be transferred from the bell, L, to coil K88, through 19, 20, 21,, bell key, A, closed, 8, 7, 6, 5, 17, 25, 28, 27, 23, 22, 4, 16, 15, 14, 13, 26, to the negative side of the battery at Y. By comparing this circuit with the one described for releasing the staff it will be seen that in the former the currents flowing through coils K360 and K88 oppose each other, and in the latter they do not, which prevents the releasing of a staff.

On arrival of the train at Y the staff is delivered to the operator, who places it in the opening, 48, Fig. 379, of his instrument, having first turned the outer guard, 37, Fig. 379, to place, moves the staff into engagement with the drum, 9, Fig. 377, revolves it through one-half turn, using the staff as a handle, and allows it to roll down the spiral. He then presses his bell key the prescribed number of times, thus notifying X that the train is out of the section, which operation also



Figs. 375-376. Electric Train Staff with Permissive and Pusher Attachments.



Figs. 377-379. Electric Train Staff Instrument.

Fig. 380. Electric Train Staff Instrument, Mounted, Showing Arrangement of Lightning Arresters.

Names of Parts of Electric Train Staff Instrument; Figs. 377-379.

1 *Back and Cover*
2 *Indicator*
4 *Locking Bar for Disk Indicator*
6 *Drum Locking Lever*
7 *Armature Raising Lever*
8 *Locking Drum Gear*
9 *Receiving Drum Gear*
10 *Operating Lever Cam*
12 *Eccentric*
15 *Terminal Post*
18 *Contact Spring*
22 *Connecting Bar*
23 *Magnet*
24 *Terminal Post*
26 *Single Stroke Bell*
29 *Contact Spring of Bell Key*
37 *Shield Plate and Knob*
38 *Glass for Indicator Opening*
39 *Slot in* 6
40 *Locking Drum*
41 *Vertical Slot*
42 *Staff Indicator Needle*
43 *Current Indicator Needle*
44 *Indicating Disk*
45 *Preliminary Handle*
46 *Push Button*
47 *Spiral Slot*
48 *Opening for Withdrawing Staff*

moves the "staff indicating needle" at X from "staff out" to "staff in." The operator at X presses his bell key in acknowledgment, and by so doing moves the "staff indicating needle" at Y from "staff out" to "staff in." The machines are now synchronized and another staff can be obtained from either in the manner outlined above. The staff being put in the the current flowing through the magnets K360, K88, are again opposing each other, consequently a staff can be released.

Cases occur where it is desirable to allow one or more trains to follow one another into the block at short intervals before the first train has passed out. This is known as the permissive system and consists of an attachment (Figs. 375-376 and

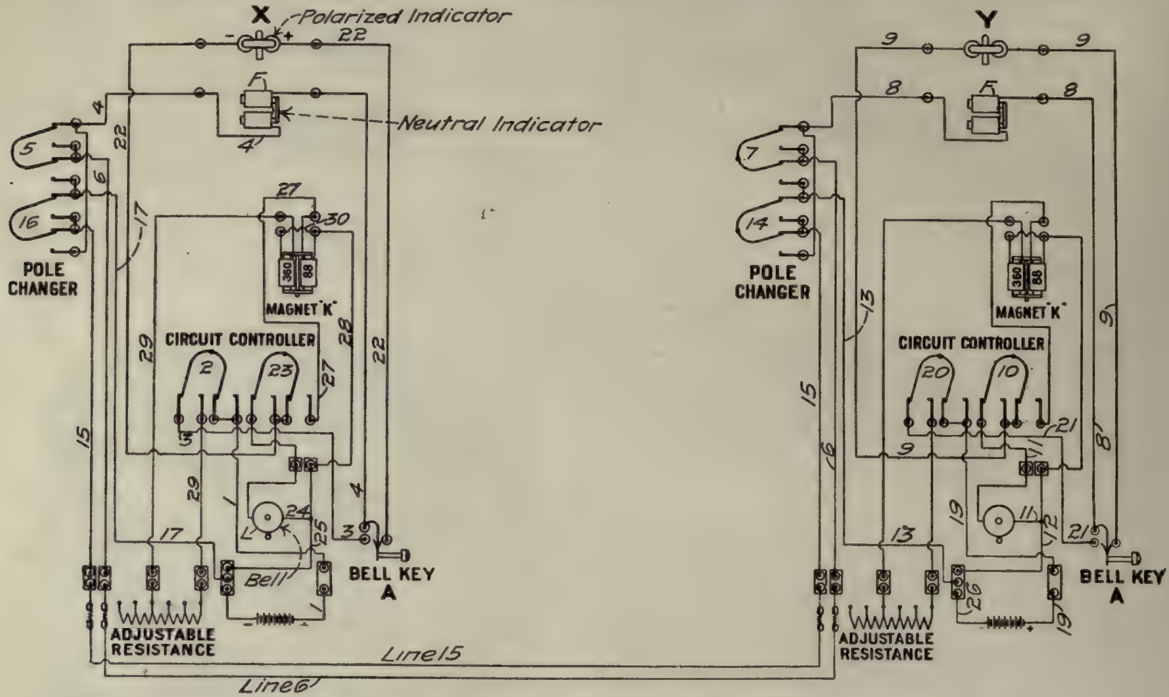


Fig. 381. Circuit for Electric Train Staff.

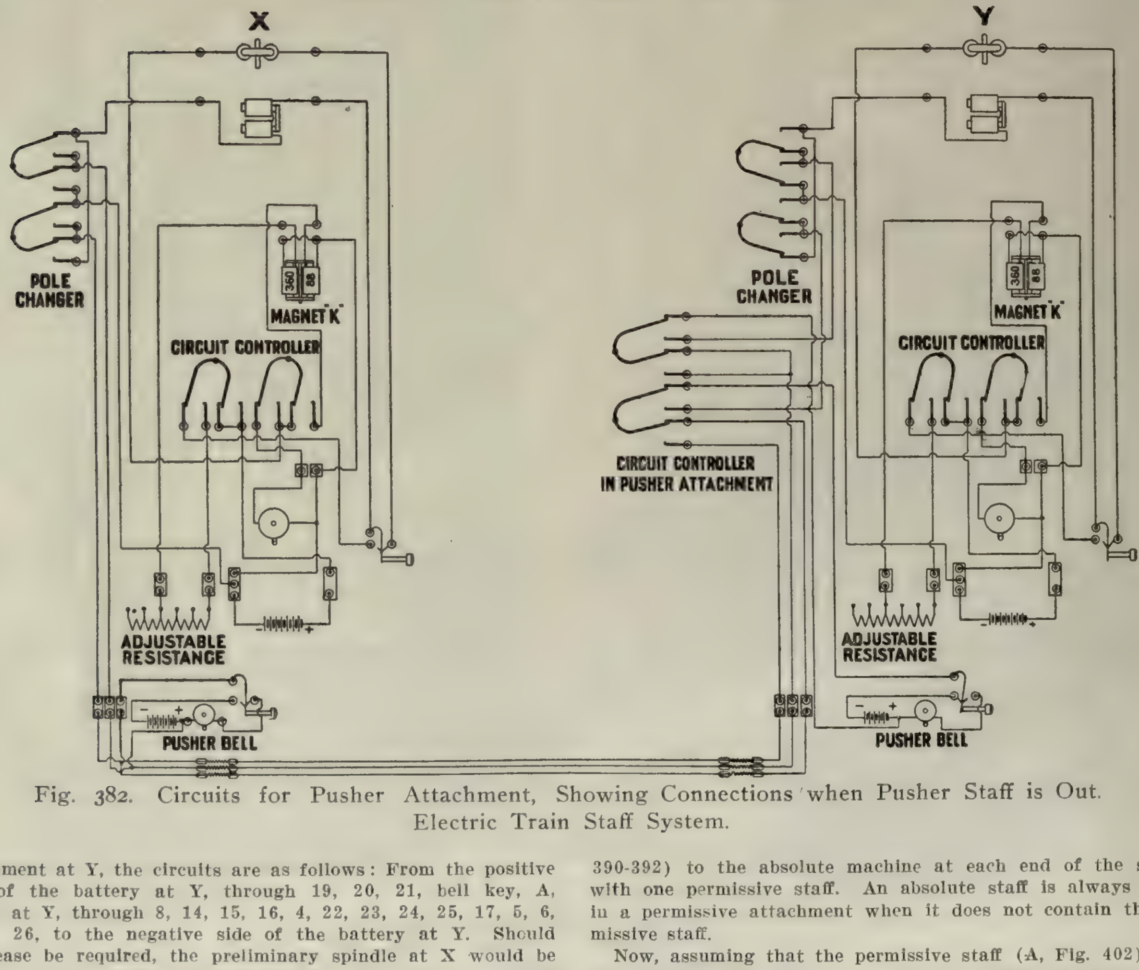
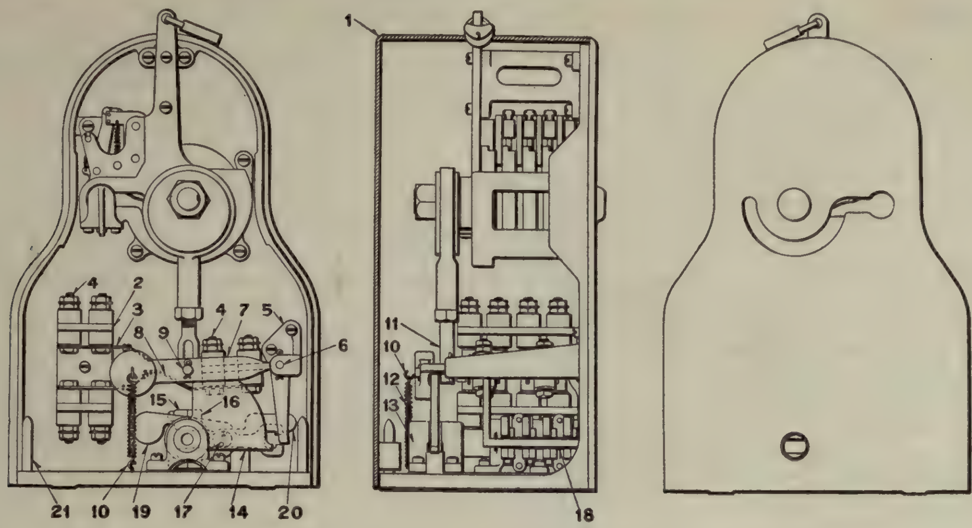


Fig. 382. Circuits for Pusher Attachment, Showing Connections when Pusher Staff is Out. Electric Train Staff System.

instrument at Y, the circuits are as follows: From the positive side of the battery at Y, through 19, 20, 21, bell key, A, closed at Y, through 8, 14, 15, 16, 4, 22, 23, 24, 25, 17, 5, 6, 7, 13, 26, to the negative side of the battery at Y. Should a release be required, the preliminary spindle at X would be turned and the current transferred from the bell to magnet K88 through the following circuit: from the positive side of the battery at Y through 19, 20, 21, bell key closed at Y, through 8, 14, 15, 16, 4, 22, 23, 27, 28, 25, 17, 5, 6, 7, 13, 26, to the negative side of the battery at Y. It will be seen that 390-392) to the absolute machine at each end of the section with one permissive staff. An absolute staff is always locked in a permissive attachment when it does not contain the permissive staff.

Now, assuming that the permissive staff (A, Fig. 402) is at X, to operate this feature, an absolute staff is withdrawn from the instrument at X in the usual manner and used as a key to unlock the attachment containing the permissive staff, which is then taken out. The opening of the base and the removal of the permissive staff locks the absolute staff in the permissive



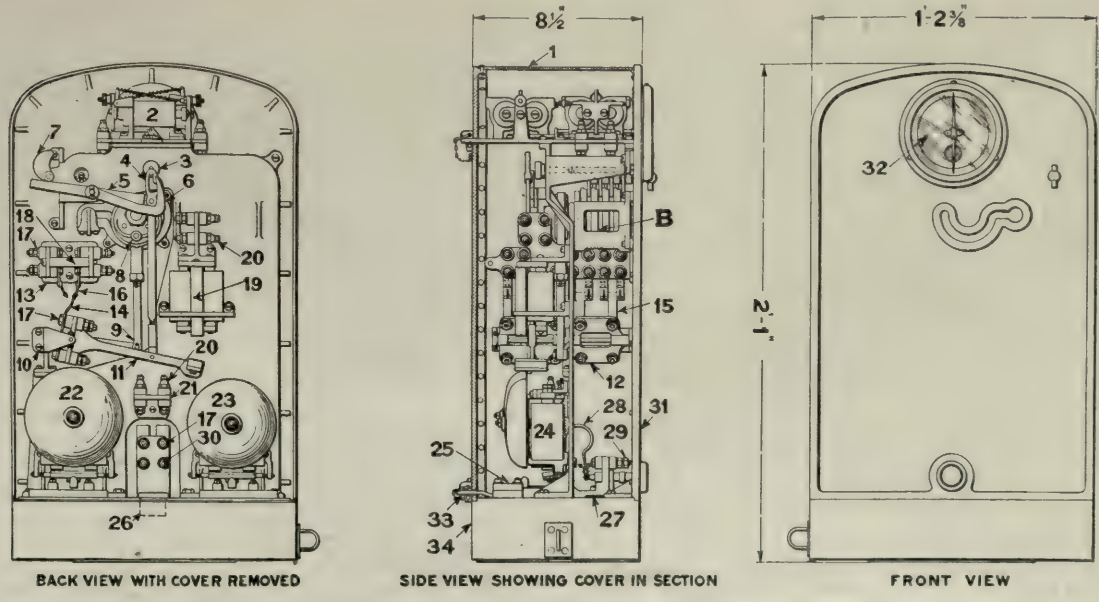
Figs. 383-385. Pusher Attachment for Electric Train Staff System.

Names of Parts of Pusher Attachment for Electric Train Staff. Figs. 383-385.

1 *Cover*
2 *Bracket for Contact Springs*
3 *Contact Spring*
4 *Terminal Post*
5 *Contact Lever Bracket*
6 *Pivot Pin for* 7
7 *Contact Lever*
8 *Contact Spring for Lever* 7
9 *Pin Connecting* 7 *with* 11
10 *Hook for Spring* 12
11 *Eccentric Rod*
12 *Releasing Spring for* 7
13 *Bearing for Locking Dog* 14
14 *Locking Dog*
15 *Right-hand Half of Socket for Pusher Staff*
16 *Left-hand Half of Socket for Pusher Staff*
17 *Pivot for Locking Levers*
18 *Separator*
19 *Long Locking Lever*
20 *Short Locking Lever*
21 *Stud for Holding Cover in Place*

Names of Parts of Intermediate Siding Staff Instrument; Figs. 386-388.

B *Locking Drum and Frame*
1 *Back and Cover*
2 *Indicator*
3 *Indicator Disk*
4 *Connecting Bar for Disk Indicator*
5 *Drum Locking Lever*
6 *Drum Locking and Armature Raising Lever*
7 *Operating Lever Cam*
8 *Eccentric*
9 *Eccentric Rod*
10 *Bracket for Supporting* 11 *and* 12
11 *Armature Lever*
12 *Lever for Pole Changer Contact Springs*
13 *Bracket for Contact Springs*
14 *Contact Spring for* 11
15 *Contact Spring for* 12
16 *Contact Spring for* 13
17 *Terminal Post*
18 *Sleeve and Machine Screw for Bracket* 13
19 *Magnet*
20 *Terminal Post*
21 *Bracket for Bell Terminals*
22-23 *Single Stroke Bells*
24 *Bell Magnet*
25 *Terminal Board*
26 *Insulating Bushing*
27 *Push Button Circuit Controller*
28 *Contact Spring*
29 *Short Contact Terminal Post for* 27
30 *Long Contact Terminal Post for* 27
31 *Front Plate*
32 *Glass for Indicator Opening*
33 *Hasp*
34 *Base*



BACK VIEW WITH COVER REMOVED — SIDE VIEW SHOWING COVER IN SECTION — FRONT VIEW

Figs. 386-388. Intermediate Siding Staff Instrument; Electric Train Staff System.

attachment, there to remain until the permissive staff is replaced. The permissive staff consists of a steel rod and eleven removable rings, any one of which authorizes a train to pass through the section to Y. If less than 12 trains are to follow each other, the last one takes all the remaining rings and the steel rod. When all the rings and the rod are received at Y, the operator reassembles them into the complete permissive staff which he then places in the base of his permissive attachment and locks it there, releasing the absolute staff already in the lock of this instrument. He then removes the absolute staff, which he restores to the absolute instrument in the regular manner. The machines are now synchronized and a movement can be made with an absolute staff in either direction, and from Y to X with the permissive. If it is again found necessary to move several trains from X to Y under the permissive system, the permissive staff must be taken out by Y, as before described, and forwarded to X as a whole by the first train moving in that direction. When the train receives the entire permissive staff it confers the same rights as does an absolute staff.

Where signals are used to indicate to an approaching train whether or not it will receive a staff (Fig. 404), an instrument known as the staff lever lock (Figs. 396-398) is attached to each lever operating such signals. To clear a signal, the staff after the staff circuits will remain broken until the handle of the circuit controller is again locked in its normal position.

If in some sections there is a siding of sufficient length to hold a train, but traffic does not warrant placing a staff block station at that point, a special instrument (Figs. 386-389) is placed at the siding, which enables it to be used for a meeting or passing point. The operation is as follows: A train arriving at the staff station X has not time to proceed to Y, but can proceed as far as the siding. The operator at X gives the train the staff with instructions to proceed to the siding. Unlocking the switch with the staff, the train takes the siding, closes and locks the switch, places the staff in the siding instrument and turns the drum to the right. The staff is now locked in the instrument and the staff instruments at X and Y are synchronized and the fact indicated to both operators, so that trains may be sent through the section in either direction. When all trains having precedence over the one in the siding have passed through the section and the staffs have been replaced in the instruments, X and Y acting in conjunction, can release the staff at the siding, which on being removed changes the circuits, so that no staff can be released at either X or Y. The train on the siding then closes the switch with the staff and proceeds to Y or back to X. A junction or diverging line may be situated between two

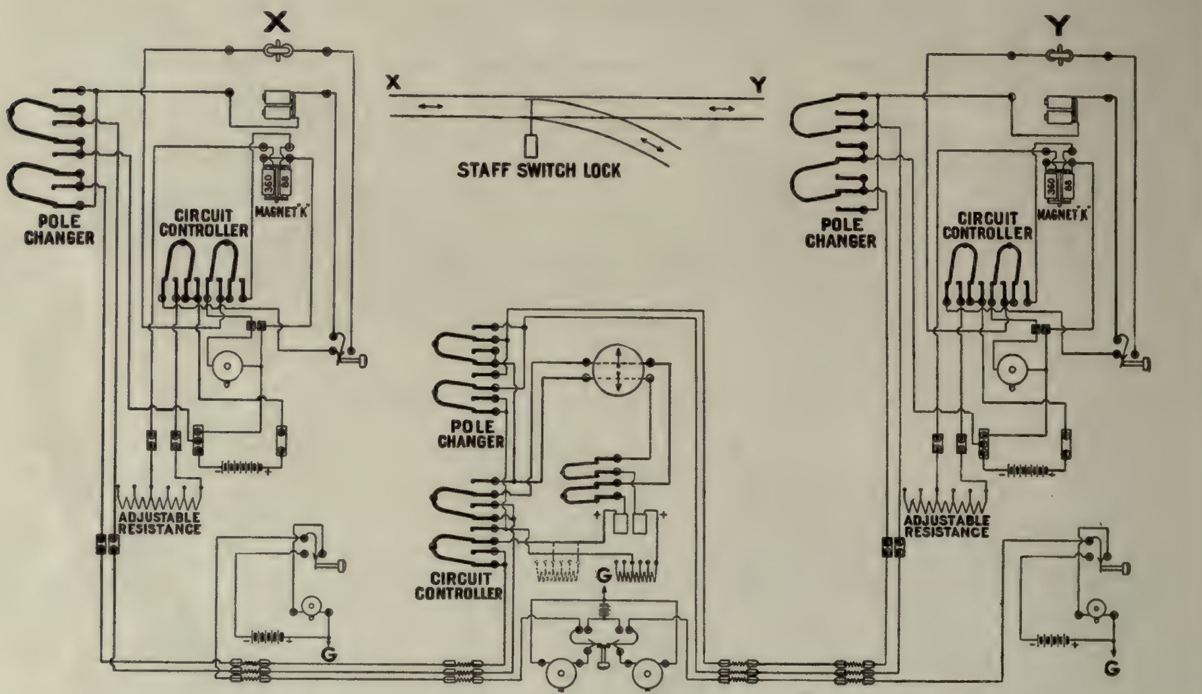
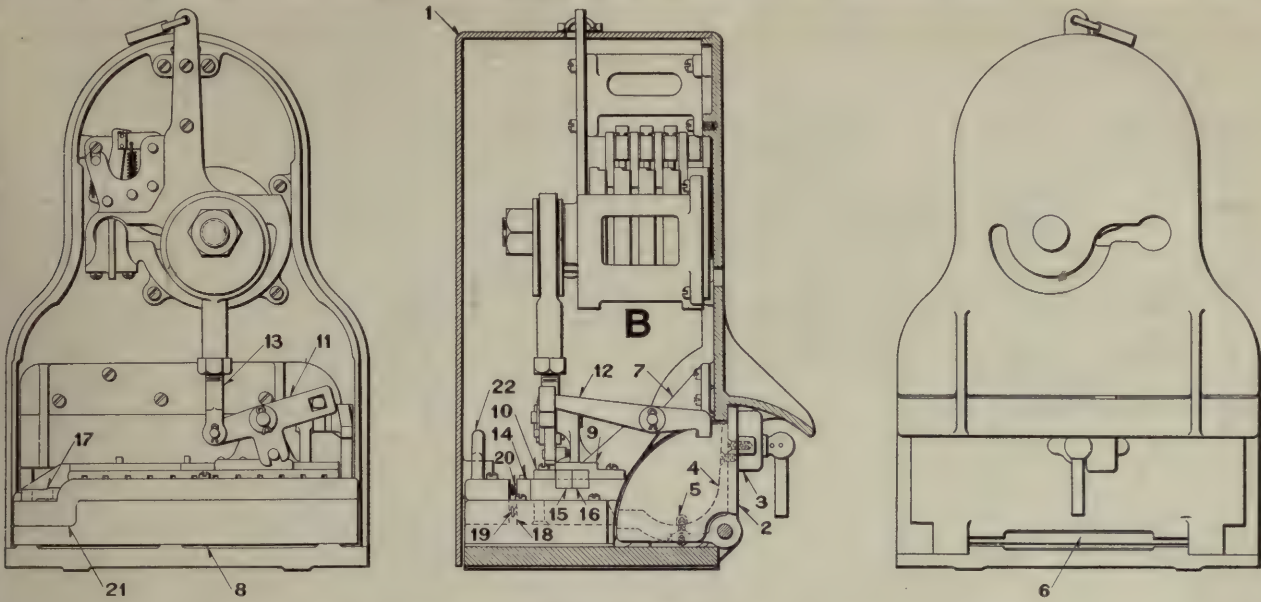


Fig. 389. Circuits for Intermediate Siding Staff Instrument; Electric Train Staff System.

being withdrawn is first used to unlock the lever lock. The signal is then cleared and the staff removed from the lock and delivered to the train. To insure the signals being restored to stop position behind the train, the act of unlocking the signal lever opens the staff circuit and no communication can be made between the two staff stations until the signal is at stop and the lever locked in that position. This does not indicate, however, that the operator will have the staff ready for delivery by hand, or in the mechanical deliverer. To cover this point, an electric slot is attached to the signal governing train movements into the staff section. This slot is controlled by the staff lever lock and the mechanical deliverer (Figs. 403-405), so that before the signal can be cleared the staff must be released, used to unlock the signal lever and put in the staff deliverer, which closes the circuit on the electric slot. The signal can then be cleared. With this arrangement, therefore, a clear signal cannot be given until the staff is actually in the deliverer. When the train picks up the staff, the circuit in the slot is opened automatically, putting the signal to danger. The signal cannot again be cleared until the operation described above is repeated. Figs. 393-395 show three views of a circuit controller attachment which is used in connection with electric or electro-pneumatic signals, instead of the mechanical lock (Figs. 396-399) just described. It is arranged to control the staff and signal circuits. The circuits controlling the signal for a movement into the staff section cannot be closed until the staff has been used to release the handle of the controller. The staff can then be taken out and given to the train, but points most suitable for staff stations. Such points can be controlled the same as a passing siding.

The staff is also used as a key to unlock siding switches, which may occur between staff stations. The switch lock (Figs. 400-401) is so designed that the staff cannot be removed from the lock until the switch is set and locked for the main line, thus providing protection against misplaced switches.

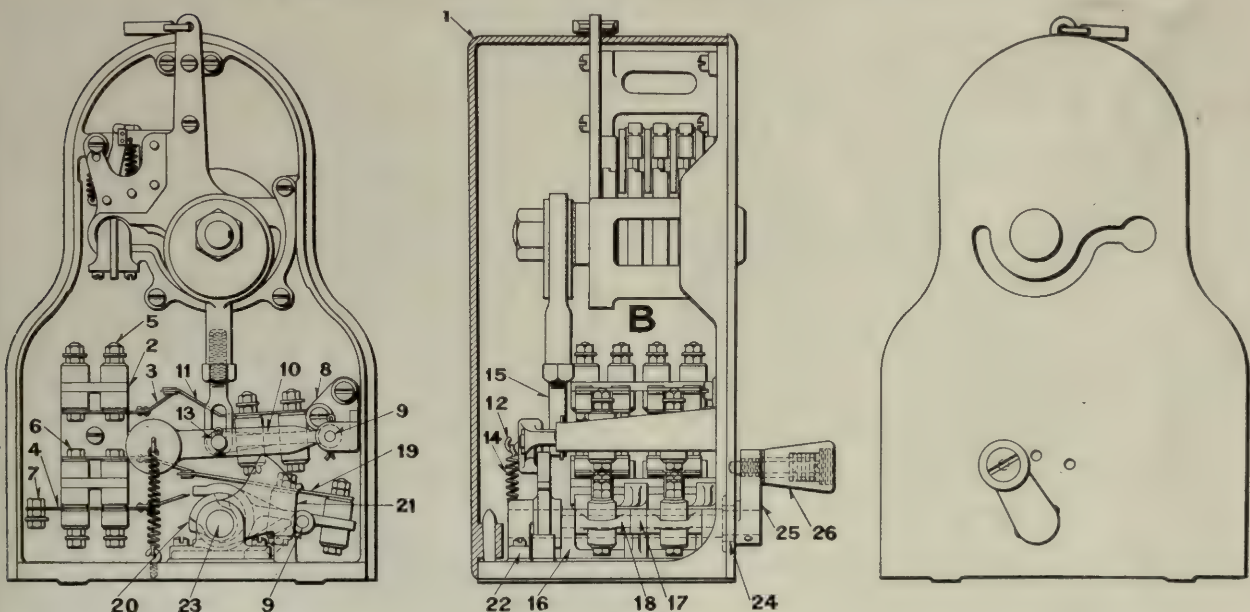
Another adjunct to the staff system is known as the pusher engine attachment and staff. It is used on heavy grades where pusher engines are required and is intended to obviate the necessity of the pusher engine preceding through the entire staff section. It is also evident that, in such cases, all the staffs would in time be brought to the bottom of the grade. It consists of a separate device which may be attached to any absolute staff instrument (Figs. 375-376 and 382-385), and contains a staff of special design (Nos. 5-8, Fig. 402), which can only be released by a regular staff, though, unlike the permissive staff, it can be out of its receptacle at the same time as the regular staff. When so removed it opens the controlling circuits of the system (Fig. 382), preventing any other movement being made until it has been returned and locked in the pusher attachment. The operation is as follows: A train with a pusher wishes to proceed from Y to X. X releases a staff at Y and Y uses this staff to release the pusher staff. Y then hands the regular staff to the train and the pusher staff to the pusher engine. The train passes through the section and delivers the regular staff at X. This is placed in the instrument there; the pusher engine retains the pusher staff and



Figs. 390-392. Permissive Attachment for Electric Train Staff System.

Names of Parts of Permissive Attachment; Figs. 390-392.

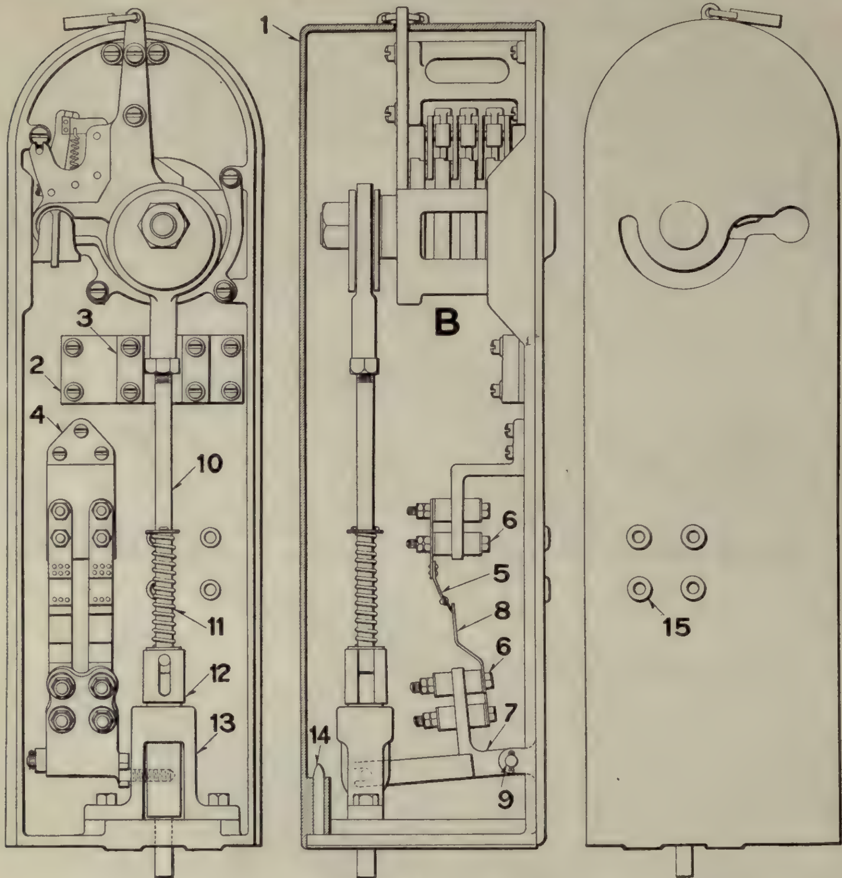
B *Locking Drum*
1 *Cover*
2 *Drawer*
3 *Drawer Lock*
4 *Cradle*
5 *Guard Bar for Permissive Staff*
6 *Hinge Pin*
7 *Permissive Staff Shield*
8 *Bed Plate*
9 *Cover Plate*
10 *Cover Bar*
11 *Eccentric Lever*
12 *Lock Lever*
13 *Eccentric Rod*
14 *Lock Bar Operated by Permissive Staff*
15 *Lock Bar Operated by Eccentric*
16 *Lock Bar Operated by* 2
17 *Crank for Operating* 16
18 *Dog for Operating* 17
19 *Spring for* 18
20 *Spring for* 14
21 *Socket for* 19 *and* 20
22 *Stud for Cover*



Figs. 393-395. Circuit Controller Attachment for Electric Train Staff System.

Names of Parts of Circuit Controller Attachment; Figs. 393-395.

B *Locking Drum and Frame*
1 *Cover*
2 *Contact Spring Bracket*
3 *Contact Spring for* 2
4 *Contact Spring with Terminal Post*
5 *Terminal Post*
6 *Long Terminal Post for* 4
7 *Short Terminal Post for* 4
8 *Bracket for* 10
9 *Pivot Pins*
10 *Contact Lever Operated by Eccentric*
11 *Contact Spring for* 10
12 *Hook on* 10 *for* 14
13 *Pin for* 10 *and* 15
14 *Spring for Releasing Lever* 10
15 *Eccentric Rod*
16 *Bracket for Contact Levers* 18
17 *Separator*
18 *Contact Lever Operated by Cam*
19 *Contact Spring for* 18
20 *Cam for Operating* 18
21 *Locking Dog*
22 *Bearing for* 23
23 *Shaft*
24 *Bushing for Shaft* 23
25 *Arm for Shaft* 23
26 *Handle*



Names of Parts of Staff Lever Lock; Figs. 396-398.

B *Locking Drum and Frame*
1 *Cover*
2 *Terminal Board*
3 *Two-Way Terminal*
4 *Bracket for Contact Springs*
5 *Contact Spring for 4*
6 *Terminal Post*
7 *Lever for Contact Springs*
8 *Contact Spring for 7*
9 *Pin with Cotters*
10 *Eccentric Rod*
11 *Eccentric Rod Spring*
12 *Plunger*
13 *Plunger Guide*
14 *Stud for Holding Cover in Place*
15 *Insulating Bushing*

Names of Parts, Staff Switch Lock; Figs. 400-401.

1 *Case*
2 *Cover*
3 *Hinge Pin*
4 *Front Plate and Base*
5 *Locking Dog*
6 *Stud for Locking Dog*
7 *Tap Bolt, for Fastening Lock to Lever*
8 *Screw, Fastening 4 to 1*
9 *Screw, Fastening 4 to 1*

Figs. 396-398. Staff Lever Lock for Electric Train Staff System.

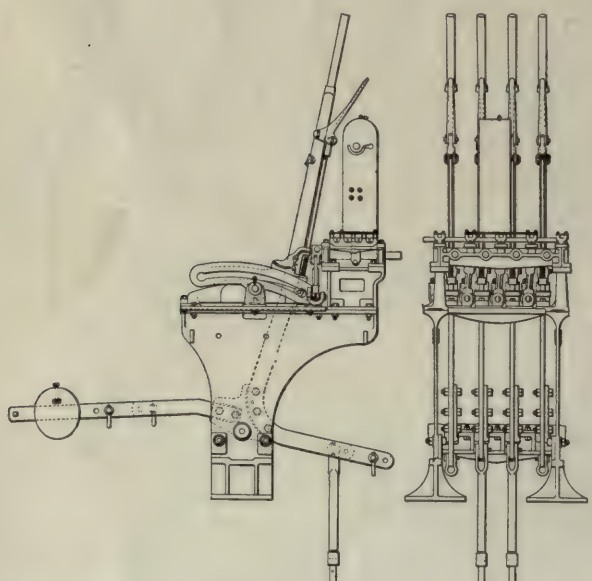
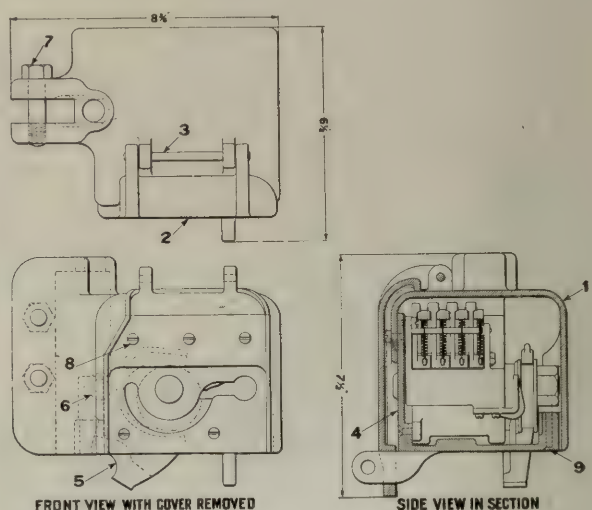


Fig. 399. Staff Lever Lock Applied to Saxby & Farmer Interlocking Machine.



Figs. 400-401. Staff Switch Lock; Electric Train Staff System.

Names of Parts of Standard, Pusher and Permissive Staffs; Fig. 402.

A *Permissive Staff Complete with Disks and Knob*
1 *Absolute Staff, No. 1*
2 *Absolute Staff, No. 2*
3 *Absolute Staff, No. 3*
4 *Absolute Staff, No. 4*
5 *Pusher Staff, No. 1*
6 *Pusher Staff, No. 2*
7 *Pusher Staff, No. 3*
8 *Pusher Staff, No. 4*

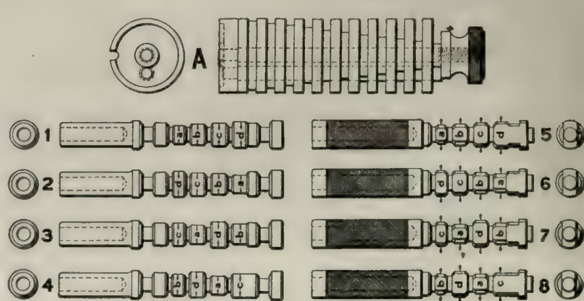
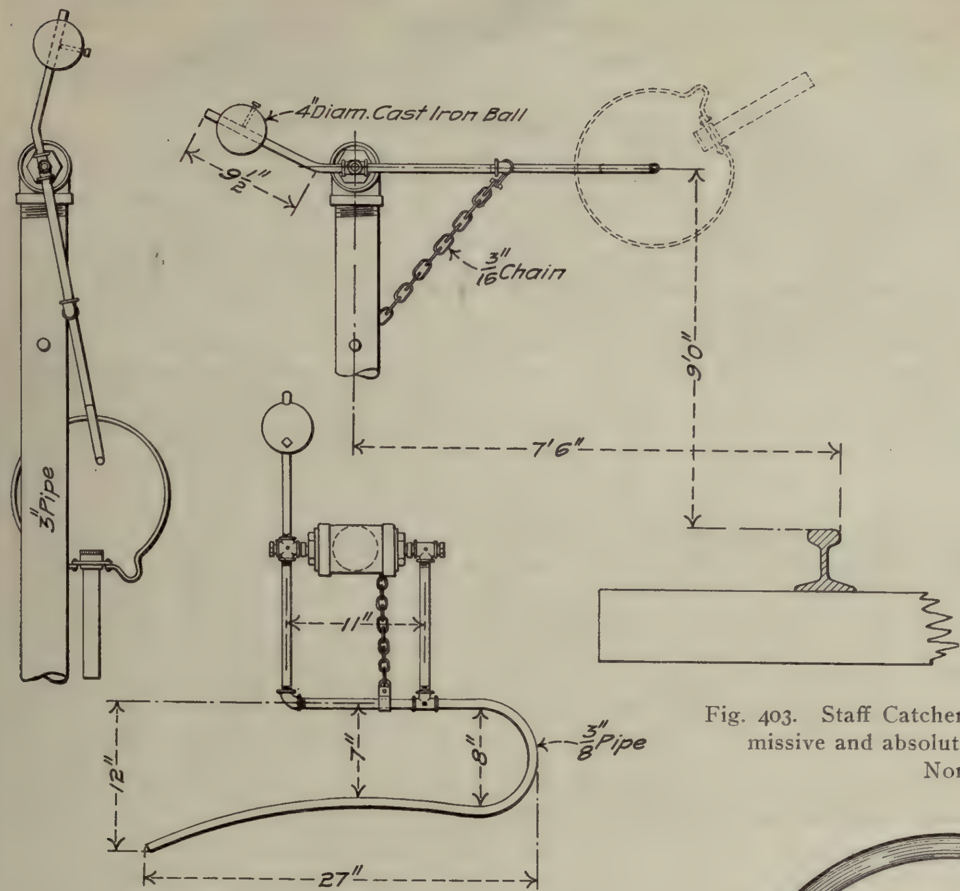


Fig. 402. Standard, Pusher and Permissive Staffs; Electric Train Staff System.



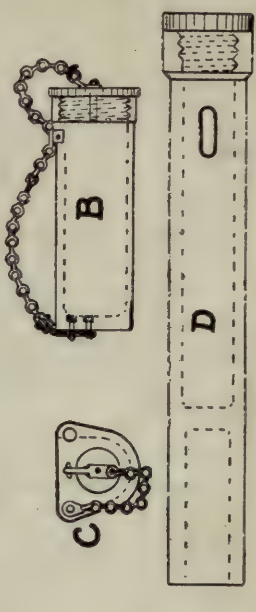


Fig. 403. Staff Catcher, Union Pacific; and Permissive and absolute Staff Pouches, Great Northern.

Fig. 404. High Speed Staff Catcher, Electric Train Staff System. Cincinnati, New Orleans & Texas Pacific.

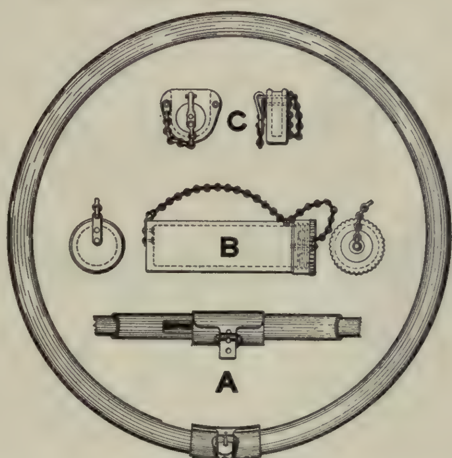


Fig. 405. Staff Catching Apparatus; Electric Train Staff System.

Names of Parts of Train Staff Catching Apparatus; Fig. 405.

A *Ring Staff Pouch*
B *Pouch for Permissive Staff*
C *Pouch for Permissive Staff Disk*

returns to Y. Until this latter staff is put into the pusher attachment at Y and locked, the staff circuits are not re-established and no other staff can be released.

Absolute staffs can be furnished in two pieces, screwed together when so desired, the object of this being to deliver one-half to the engineman and the other half to the conductor of the train, so that should a train break in two and part remain in the section, the forward portion, on leaving the section, would deliver only one-half of the staff, which would not be sufficient to unlock the machine.

To avoid the possibility of the staff belonging to one pair of instruments in a continuous installation being used to unlock one of another pair at either end of the block, staffs are made in four different patterns (Nos. 1-4, Fig. 402), so that it would be necessary to carry one staff improperly through three entire blocks before reaching one where it would fit an instrument.

AUTOMATIC

THE TRACK CIRCUIT

The track circuit, which is the vital feature of modern block signaling and has made the present high development of the art possible, is a simple electrical device. Its essential feature is a section of track insulated at each end from the adjoining sections of the track. Each rail in the section is connected to the ones adjoining by bond wires, for the purpose of making a continuous conductor from one end of the section to the other. The contacts made by ordinary rail splices are not good electrically, owing to wear, rust and the loosening of bolts. Two bond wires are usually used at each joint, so that should one break, the circuit will remain continuous through the other. These bond wires are secured to the rail by means of "channel pins" or other suitable devices. On electrically operated roads where tracks are bonded for the return propulsion current with heavy copper bonds, no additional bond wires are necessary. At one end of the insulated track section a battery is placed, the positive terminal being connected to one rail and the negative terminal to the other. At the other end of the section a relay is connected to the rails in a similar manner. Fig. 406 shows a typical track circuit. Current flows from the positive side of the battery through the lower rail, the relay and the upper rail back to battery. This keeps the relay energized.

The track relay is a development of the instrument of the same name used in the telegraph. It consists of an electro-magnet of the horse-shoe type, provided with an armature. The armature is attracted to the magnet when the latter is energized and is drawn away by gravity or by a spring when the magnet is de-energized. The armature carries one or more fingers for making or breaking electric circuits through points or stops.

The presence of a pair of wheels or train in the section will short-circuit the battery, shunting the current out from the relay and causing its armature to drop, because the resistance through the wheels and axle of an ordinary car or engine is infinitesimal compared with that of a relay of three and a half ohms or more. Consequently the relay is deprived by the wheels and axles of current necessary to maintain its attractive power for the armature. The minimum resistance usual in track relays is three and a half ohms. Fig. 407 shows the effect of a train on the track circuit; the train is assumed to be passing from the relay end to the battery end of the section. The effect would be the same should the train move in the opposite direction with respect to the battery and relay (Fig. 408), except that the relay would not release quite so quickly. This is in part due to the self-induction of the circuit through the relay coils, the rails and the axles of the train. It is due more, however, to small leakage from the adjoining section and the effects of stray earth currents which are always present to a greater or less degree. A broken rail would also open the circuit and de-energize the relay.

Circuits for the control of various signaling devices are

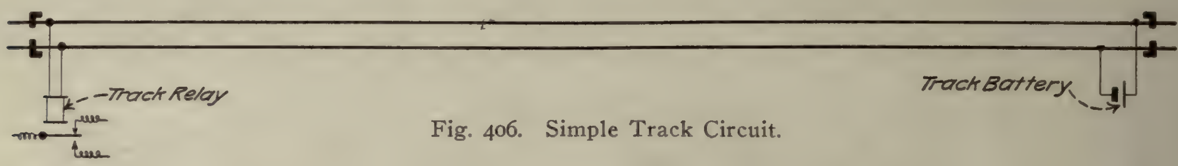


Fig. 406. Simple Track Circuit.

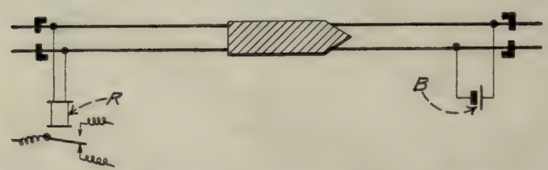


Fig. 407. Track Circuit Occupied by Train Moving from Relay to Battery.

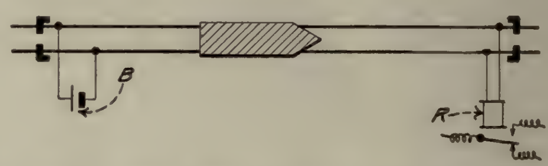


Fig. 408. Track Circuit Occupied by Train Moving from Battery to Relay.

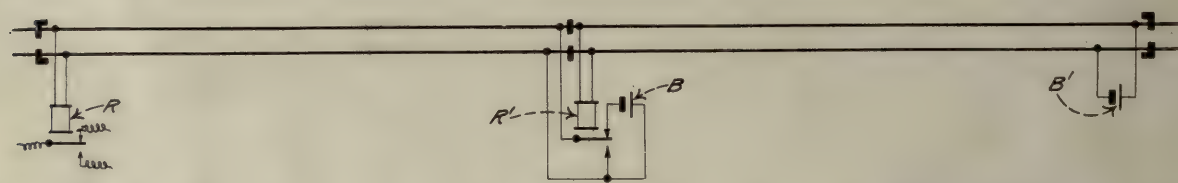


Fig. 409. Cut Section Track Circuit—a Single Block Section Divided in the Middle Because of Difficulty in Operating Long Track Circuits.

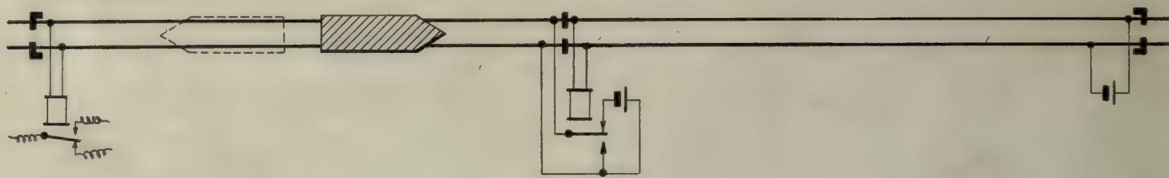


Fig. 410. Cut Section Track Circuit. Train in Relayed Half.

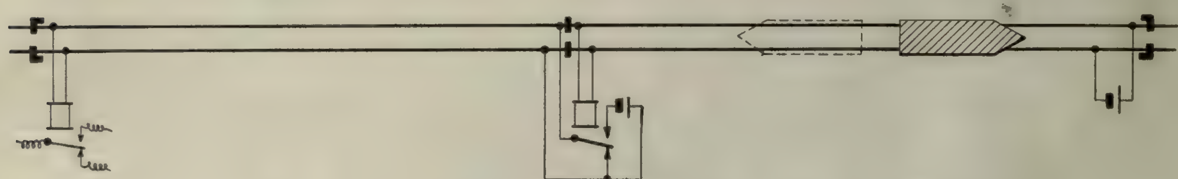


Fig. 411. Cut Section Track Circuit. Train in Relaying Half.

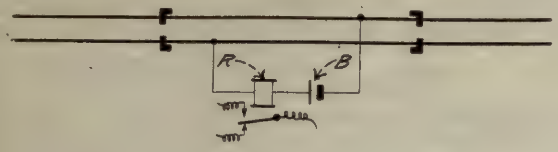


Fig. 412. Normally Open Track Circuit.

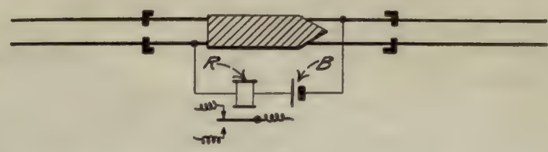


Fig. 413. Normally Open Track Circuit Occupied by Train.

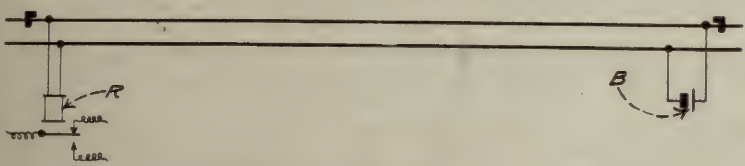


Fig. 414. "Single Rail" Track Circuit, Normally Closed.

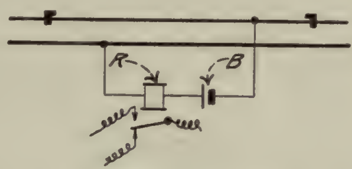


Fig. 415. "Single Rail" Track Circuit, Normally Open.

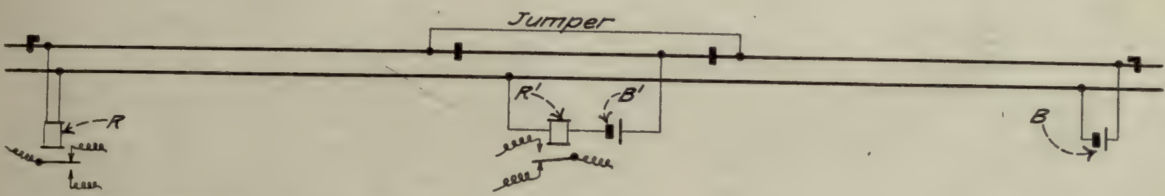


Fig. 416. Normally Closed Track Circuits, with Normally Open Track Circuit Superimposed.

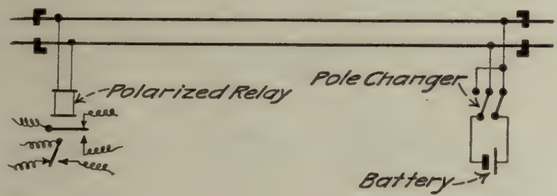


Fig. 417. Simple Polarized Track Circuit; Pole Changer Normal.

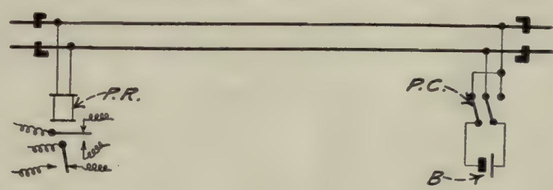


Fig. 418. Simple Polarized Track Circuit; Pole Changer Reversed.

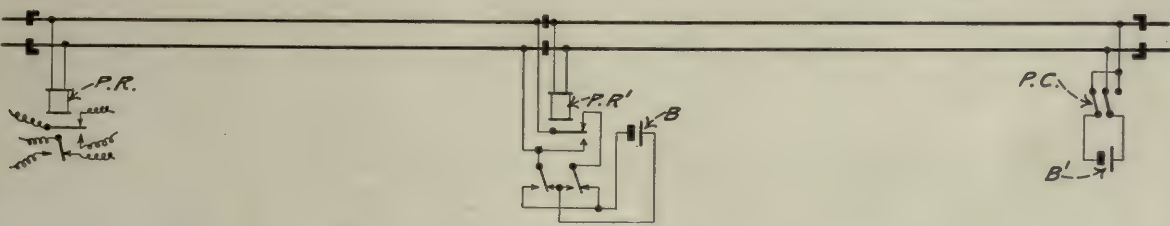


Fig. 419. Cut Section, in Polarized Track Circuit; Pole Changer Normal.

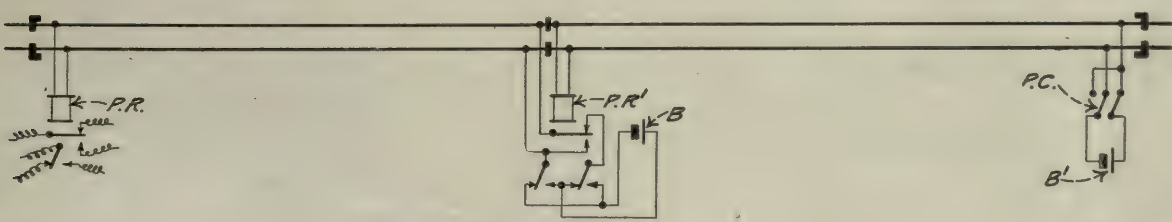


Fig. 420. Cut Section, in Polarized Track Circuit; Pole Changer Reversed.

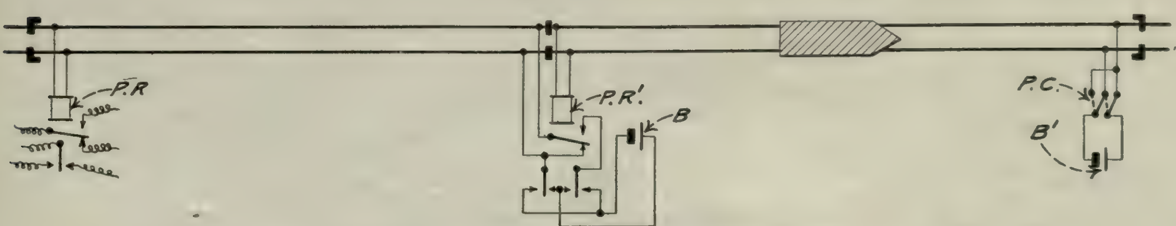


Fig. 421. Polarized Track Circuit with Cut Section, Relaying Section Occupied by Train.

broken through the contact points of the track relay. Such apparatus cannot be operated directly by the track circuit because to furnish it with sufficient current a battery of large electro-motive force would be needed. On account of the low insulation resistance of the ties and ballast it is unwise to use a battery of more than about two volts potential. With any higher voltage the leakage from rail to rail, especially in wet weather, becomes equivalent to the presence of a train in the section. For the same reason track circuits cannot be made of unlimited length. The resistance of the rails also has to be considered in determining the length of a track circuit.

Almost any kind of closed circuit primary battery can be used

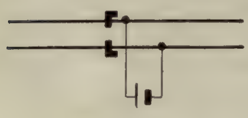


Fig. 422.

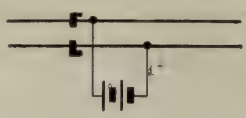


Fig. 423.

Fig. 424.

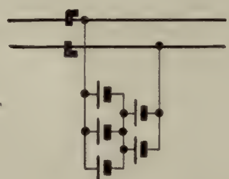
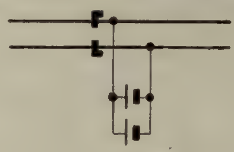
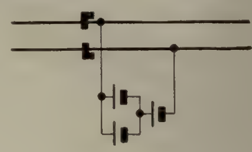


Fig. 425.

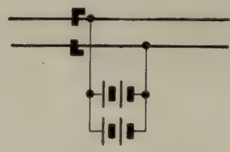
Figs. 422-425. Possible Arrangements of Cells of Track Circuit Battery.



"A"



"B"



"C"

"D"

Figs. 426-429 Common Arrangements of Cells of Track Circuit Battery. The Letters Refer to the Curves, Fig. 430.

to supply current to a track circuit, but in practice gravity or storage is ordinarily used. Gravity battery is used to a greater extent than any other type of primary battery on account of its suitability to closed circuit work. It has a high internal resistance compared with its electro-motive force, and therefore will not exhaust as rapidly as other types. Potash or soda batteries might be used by inserting resistance, in the same manner as with storage battery, except that they are found not to be so economical in practice. When gravity battery is used not more than two cells are usually placed in series. Figs. 426-429 show various arrangements of this type in general use for track circuits. The following table shows the maximum current flowing under certain given conditions. In this table 1.079 volts is taken as the maximum initial E. M. F. of a gravity cell, and two ohms as the minimum internal resistance.

	Maximum current (in milli-amperes).		
	Track shunted.	Through 9-ohm relay.	Through 3½-ohm relay.
Fig. 422..........	539.5	98.09	196.18
Fig. 426..........	1,079.0	107.9	239.78
Fig. 429..........	1,618.5	111.62	258.96
Fig. 423..........	539.5	166.0	287.73
Fig. 427..........	719.33	179.83	332.0
Fig. 428..........	1,079.0	196.18	392.36
Fig. 425..........	1,294.8	202.31	417.68
Fig. 424..........	1,618.5	208.84	446.48

For the purposes of the above table the resistance of the rails and of the battery and relay leads is disregarded, also that of the ties and ballast. In calculating the table Ohm's law is used in the form $I = \frac{E \times 1000}{(B + R)}$, where I is the current, in milli-amperes, E is the electro-motive force in volts, B the internal resistance of the battery in ohms, and R the external resistance of the circuit (relay) in ohms. The factor 1000 is used in the numerator to reduce the result to milli-amperes. Where cells are placed in multiple or parallel the internal resistance of the battery is reduced in proportion to the number of cells; two cells reduce it to ½, three cells to ⅓, etc. Where cells are placed in series the internal resistance is increased proportionately to the number of cells; with two cells it is twice as much, three cells three times as much, etc.

The electrical characteristics of the various arrangements are shown in the table. Their mechanical characteristics will now be considered. Fig. 422 is seldom used, for the reason that should the jar break or any other accident happen to the cell, the circuit would fail to operate. Fig. 426 ("A"), two cells in multiple or parallel, is the usual arrangement. It guards against failures, as the chance of accident to both cells at the same time is remote. Also the cells can be renewed alternately, thereby assuring a uniform output of the battery as a whole. Fig. 429 ("D"), three cells in parallel, is a further development of Fig. 426 ("A"). It also secures a slightly lower internal resistance with consequent increased output. Fig. 423, two cells in series, like Fig. 422, is rarely used, and for the same reason Fig. 427 ("B"), two cells in multiple with one in series, is rather liable to failure, but has electrical advantage, as can be seen from the table. With this arrangement it is customary to rotate the cells from one place in the battery to another at the times of inspection and renewal. Fig. 428 ("C") four cells in series multiple, is frequently used for long or wet sections; it will be noted that it is a development of Figs. 426 ("A") and 423. Fig. 425 is a development of Fig. 427 ("B"), and Fig. 424 of Fig. 428 ("C").

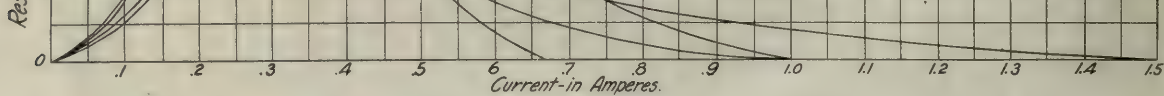


Fig. 430. Performance of Track Circuit Battery Under the Four Arrangements Shown in Figs. 426-429.

The curves in Fig. 430 show, at the left, the amount of current, in milli-amperes, that passes through a four-ohm relay for each of the connections, A, B, C and D, with the track resist-

Fig. 431. Wedged Switch in Track Circuit. (Switch rail separated by wedges from electrical connection with main rail.)

Fig. 432. Switch in Track Circuit; One Rail Cut Out.

Fig. 433. Insulated Switch, with Siding Rails Electrified to Fouling Point, D E.

Fig. 434. Insulated Switch, with Fouling Protection. Chicago & North-Western.

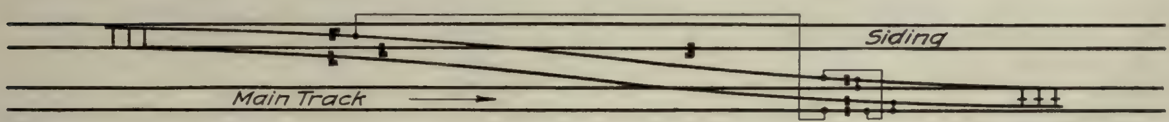


Fig. 435. Siding Crossover in Track Circuit. Chicago & North-Western.

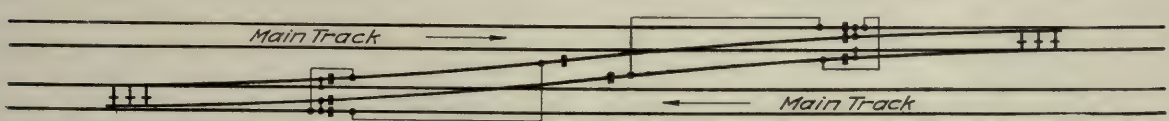


Fig. 436. Main Line Crossover in Track Circuit (Left-Hand Running). Chicago & North-Western.

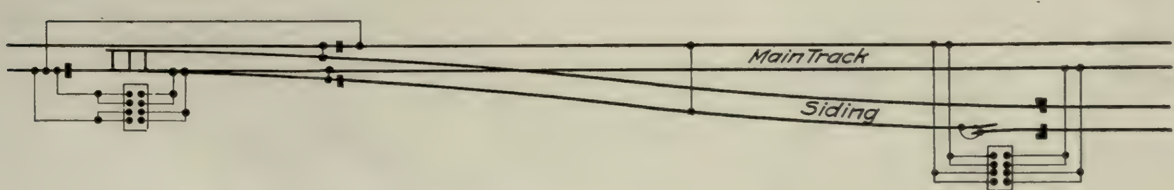


Fig. 437. Protection for Switch in Main Track and Derail in Siding.

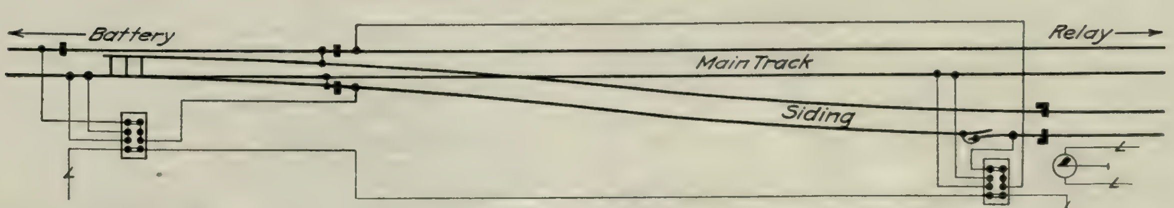


Fig. 438. Protection for Switch and Siding Derail; Siding Rail in Series.

ance varying from 0 to 4 ohms. The curves to the right show the total amount of current in the circuit for each of the four connections with the same range of roadway resistance. It is evident that the variation in the amount of current is not so great when the roadway resistance is high. When this is the case the connection that will furnish the least amount of current that will operate the relay is the most desirable, since it is the most economical. Inasmuch, however, as the average track circuit is subject to conditions which reduce its resistance at times, the particular arrangement that will give the maximum of current when the leakage in the section is considered is the one that should be used. It is seen that connection A gives the least amount of current with a high roadway resistance, and its volume increases to a total of one ampere when the roadway resistance is the lowest possible. Connection B gives more current under dry conditions, but when the roadway resistance drops the volume of current is not increased as much as that given by A. C gives more current than either A or B under dry conditions, and shows a better

circuits, one controlled by the other. Fig. 410 shows a train in the first section. The relay R′ of the second section breaks and shunts the circuit of the first section when the train is in the second (Fig. 411). As with the single track circuit, results are practically the same whichever way the train is moving. It should be noted that the shunting effect of the back contact point of relay R′ is applied to the track and not to the battery. This is to shunt out any foreign current that may have leaked into the section and would be liable to energize the relay R. It also prolongs the life of battery B.

The track circuits above considered were normally closed. Normally open circuits are also used to a limited extent. Fig. 412 shows such a circuit. Here the relay is normally deenergized, as there is no connection between the rails. The presence of a train on the circuit, Fig. 413, picks up the armature opening or closing control circuits through its contact points. Current flows from positive side of battery to one rail, through the wheels and axles of the train to the other rail, through the relay and back to the battery. This kind of circuit

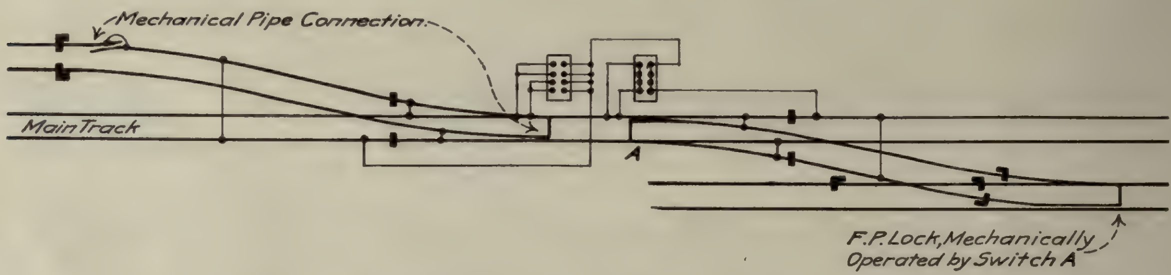


Fig. 439. Transposition and Protection for Two Switches.

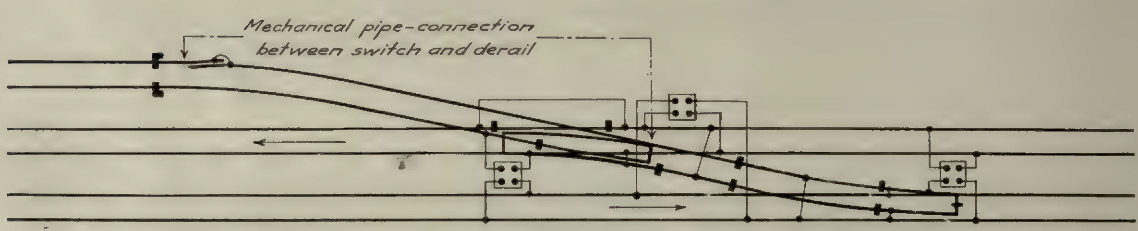


Fig. 440. Protection for Main Line Crossover and Slip Switch.

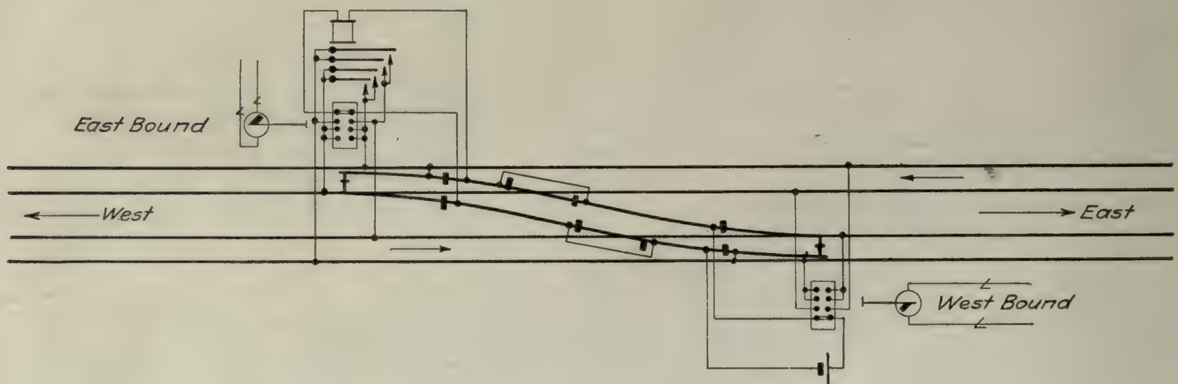


Fig. 441. Track Circuit for Main Line Crossover. Illinois Central.

performance than the others when the roadway resistance is low. D, for the average condition, seems to be the best of the four, as it shows a more economical output under dry conditions, and takes care of the low resistance conditions with a much greater volume of current than the other arrangements.

The use of secondary or storage battery has been referred to. When this is used it is necessary to insert a resistance in one or both battery leads to restrict the flow of current and prevent the battery from becoming exhausted by the passage of one train, and otherwise injured by over-discharge.

Where it is necessary to control signaling apparatus by track circuits over such a length of track that one circuit would not work, two or more circuits are employed. The control circuits may be broken through the relays of the successive track circuits, or "cut sections" may be introduced. Fig. 409 shows this latter arrangement, which consists of two adjacent track

is used principally for annunciators. Here only one rail in each part of the circuit is insulated, but this does not in any way affect its operation. A train on any track between the insulated joints will complete a circuit as in Fig. 413. In normally open track circuits the resistance of the relay should be lower than in normally closed. Their use is necessarily limited to track sections of a few rail lengths only; in longer sections the low insulation resistance from rail to rail would allow the flow of enough current to hold up the relay after a train had passed out of the section. Gravity battery should not be used unless the traffic is very heavy, as a gravity cell soon deteriorates and becomes inoperative on an open circuit.

The use of normally open track circuits is also limited on account of the fact that there is no certainty that the relay will pick up. Any failure of the apparatus, such as a broken rail, exhaustion or breakage of the battery cell, or breakage at

any of the wires, will render the apparatus inoperative. Such failures are not readily detected, as they merely maintain the apparatus in its normal condition. With a normally closed circuit the reverse is true. Here any failure will be almost immediately detected, and will be on the side of safety.

Figs. 414 and 415 show the same circuits as Figs. 406 and 412, except that only one rail is insulated. These are some-

Fig. 416 is a special arrangement. A normally open track circuit is placed within the limits of a normally closed circuit. This shows one advantage of insulating only one rail. The uninsulated rail is common to both circuits, and the necessity of a second "jumper" to carry one circuit past the other is avoided. Such an arrangement might be used when it is necessary to announce a train from some point within a signal track circuit.

Fig. 442. Common Location of Insulated Joints at Switch.

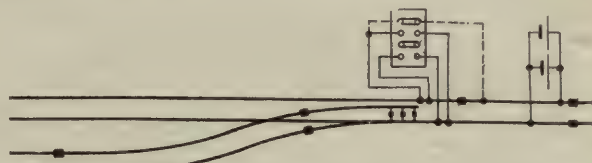


Fig. 443. Switchbox Arranged to Shunt Track Circuit.

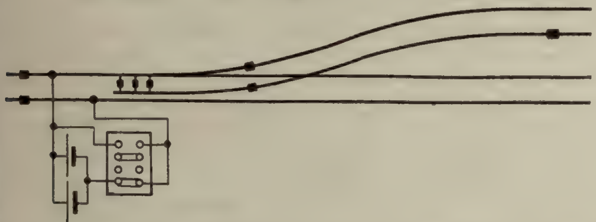


Fig. 444. Wiring when Battery is Located at Switch.

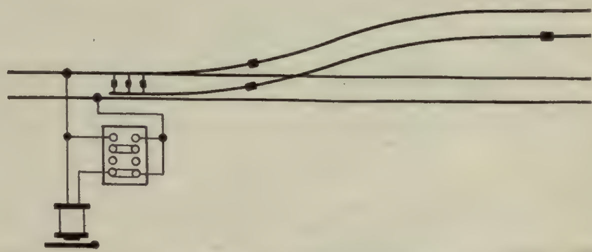


Fig. 445. Wiring when Relay is Located at Switch.


Fig. 446. Shunt Circuit.


Fig. 447. Series Fouling Circuit.


Fig. 448. Alternate Circuit for Series Fouling.

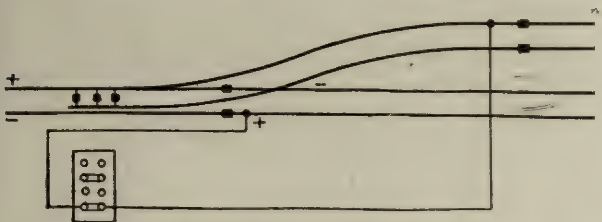


Fig. 449. Series Fouling, Changing Polarity.

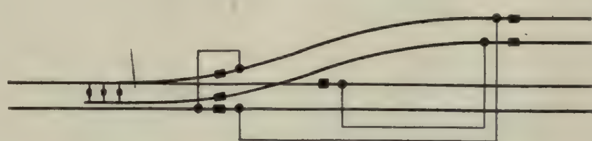


Fig. 450. Both Turnout Rails in Series.

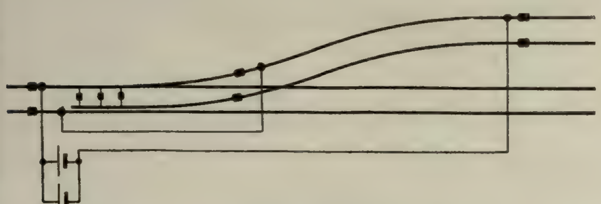


Fig. 451. Battery Located Just Ahead of Switch Points.

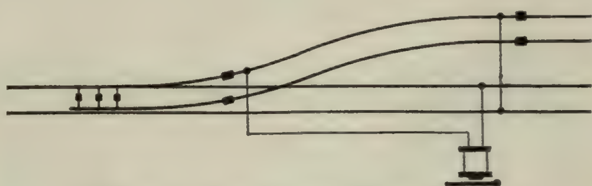


Fig. 452. Relay Located Near Switch.

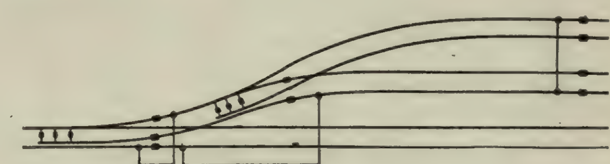


Fig. 453. Double Turnout.


Fig. 454. Lap Switch.


Fig. 455. Wiring for Interlocked Switch.

Figs. 442-455. Track Circuit Wiring at Switches.

times termed "single rail" circuits. Installations of this kind are made to avoid the expense of two insulated joints or where one rail is needed for another circuit. Such track circuits are more liable to failure than those having both rails insulated, for the reason that the breakdown of one insulated joint will extend the circuit beyond its proper limits and cause interference with neighboring circuits and premature or extended shunting of the relay, due to the presence of a train beyond the insulated joints.

In Figs. 417 and 418 is shown a track circuit in which the direction or "polarity," as well as the presence of current, is made use of at the relay. By this means two separate functions may be performed by one track circuit, provided that the first or principal function, actuated by the presence (or absence) of current, does not interfere with the secondary function, actuated both by the presence of current and its polarity. For example, in a two-arm (home and distant) automatic signal the home signal is controlled by its immediate track circuit,

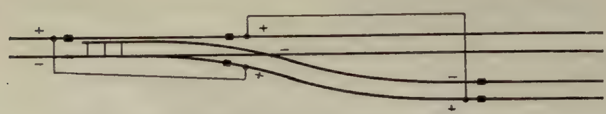


Fig. 456. Wiring for Interlocked Switch.


Fig. 457. Wiring for Junction Point.

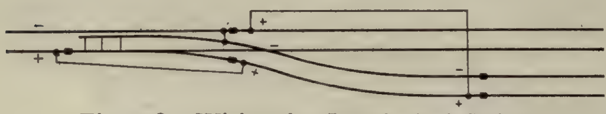


Fig. 458. Wiring for Interlocked Switch.


Fig. 459. Crossover Wiring to Protect One Track.

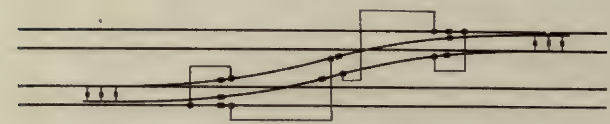


Fig. 460. Crossover Wiring to Protect Both Tracks.

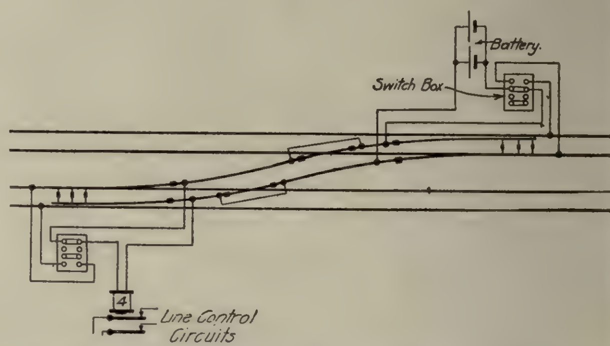


Fig. 462. Independent Track Circuit for Crossover.

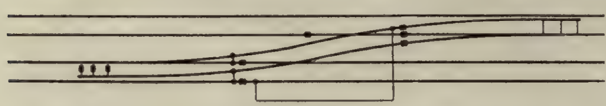


Fig. 461. Series Fouling Reversing Polarity.

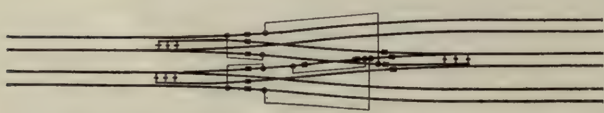


Fig. 463. Wiring for Two Tracks Diverging to Three.

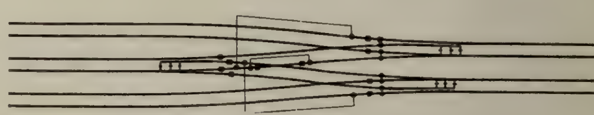


Fig. 464. Wiring for Two Tracks Diverging to Three.

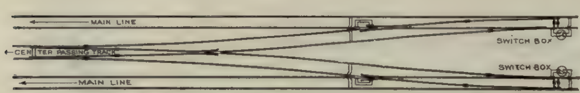


Fig. 465. Wiring for Entrance to Center Passing Track.

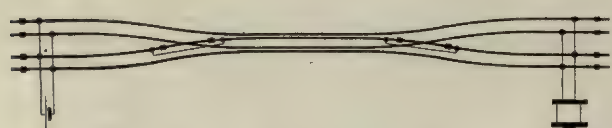


Fig. 466. Wiring for Gauntleted Tracks. Incomplete Protection.

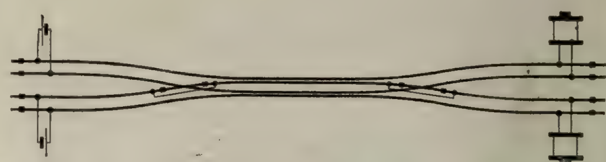


Fig. 467. Gauntleted Tracks Properly Protected.

Figs. 456-467. Protective Wiring.

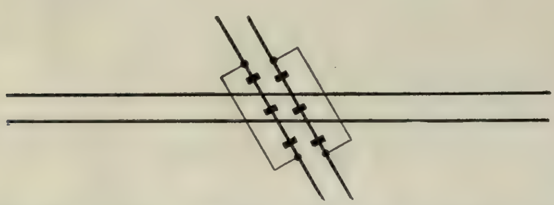


Fig. 468. Track Circuits Through Crossing; Two Rails Continuous.

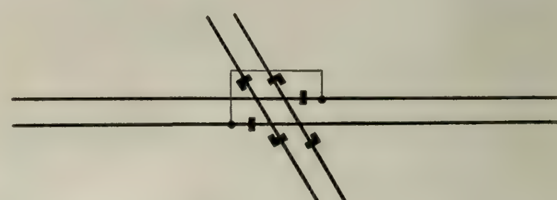


Fig. 469. Transposition of Track Circuit at Crossing.

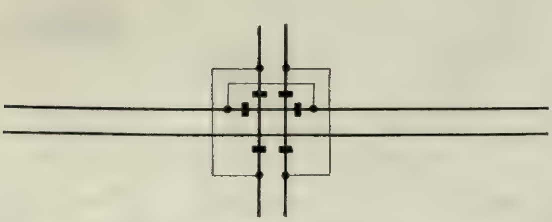


Fig. 470. Track Circuits Through Crossing; One Rail Continuous.

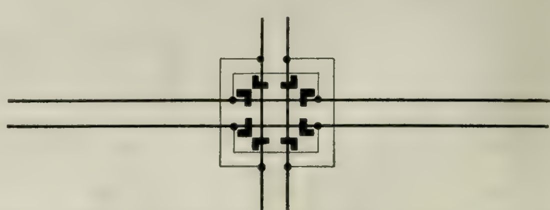
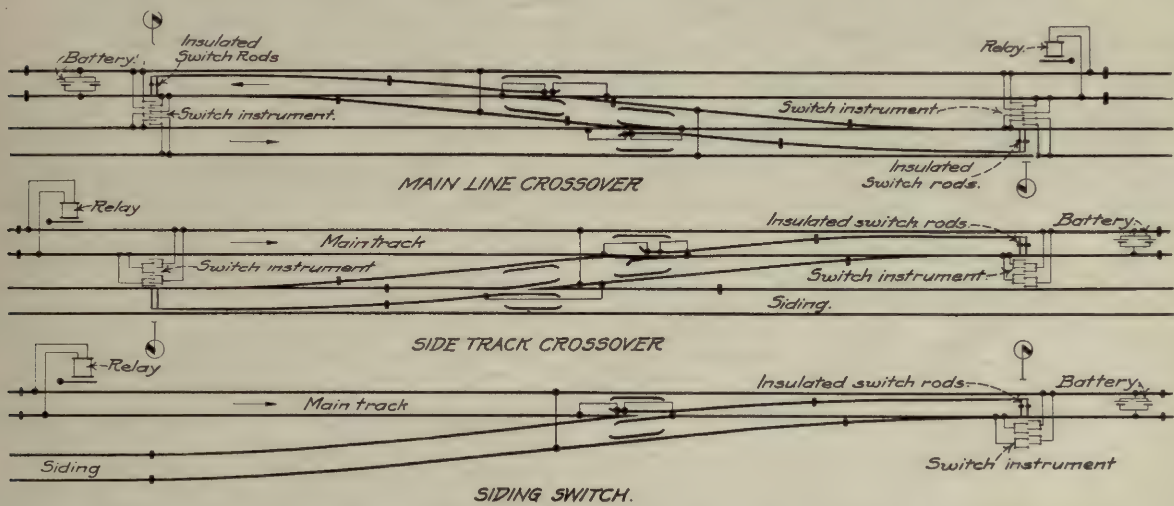


Fig. 471. Track Circuits Through Crossing; Four Jumpers.

while the distant must be controlled by this circuit and the position of the next home signal in advance.

In place of the ordinary track relay, one of special design called a polarized relay is used. Such a relay is constructed like an ordinary track relay, except for the addition of a polarized armature. In its simplest form this armature would consist of a permanent magnet, one extremity of which would be free to swing between the pole pieces of the electro-magnet. As like magnetic poles repel each other, and unlike attract, and



Figs. 472-474. Switch and Crossover Protection. New York Central & Hudson River.

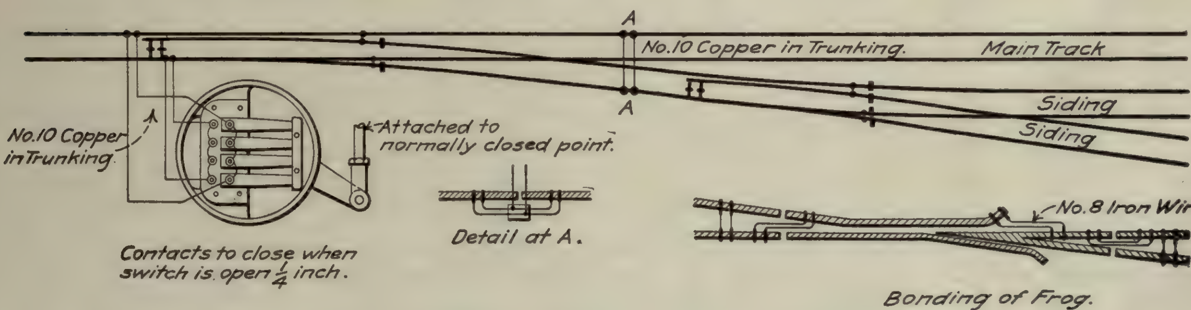


Fig. 475. Switch Wiring and Fouling Protection. Southern Pacific.

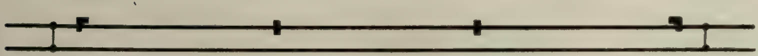


Fig. 476. Protection Against Foreign Currents; "Single Rail" Track Circuits; Jumpers at Each End.

Fig. 477. Foreign Current Protection; Isolated Two-Rail Track Circuit.

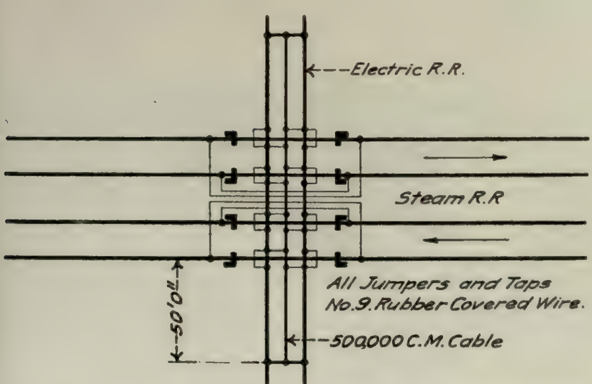


Fig. 478. Bonding at Crossing of an Electric Railroad. Chicago & North-Western.

as a reversal of the direction of flow of current in the coils of an electro-magnet reverses the polarity of the magnet, it can readily be seen that with the track circuit flowing in one direction, the polarized armature would be attracted to one pole of the magnet, and vice versa. Change of direction in the track circuit current is effected by the pole changer shown. This is actuated by any desired means, such as a lever, signal arm, etc. Current flows from positive side of battery through left-hand arm of pole changer, through lower rail, relay, upper rail, right-hand arm of pole changer, back to battery. The polarized armature carrying contacts is deflected to the left and makes contact with the front point. With the pole changer reversed (Fig. 418), current flows from positive side at battery through the left arm of pole changer, upper rail, relay, lower rail, right-hand arm of the pole changer, back to battery, and the polarized armature is deflected to the right, making contact with the back point. It should be noted that in both cases the neutral or ordinary armature is attracted as in an ordinary track circuit. Thus a circuit entirely separate from one through the neutral points can be controlled from beyond the track circuit, by means of the track circuit itself, without interfering with the one through the neutral points.

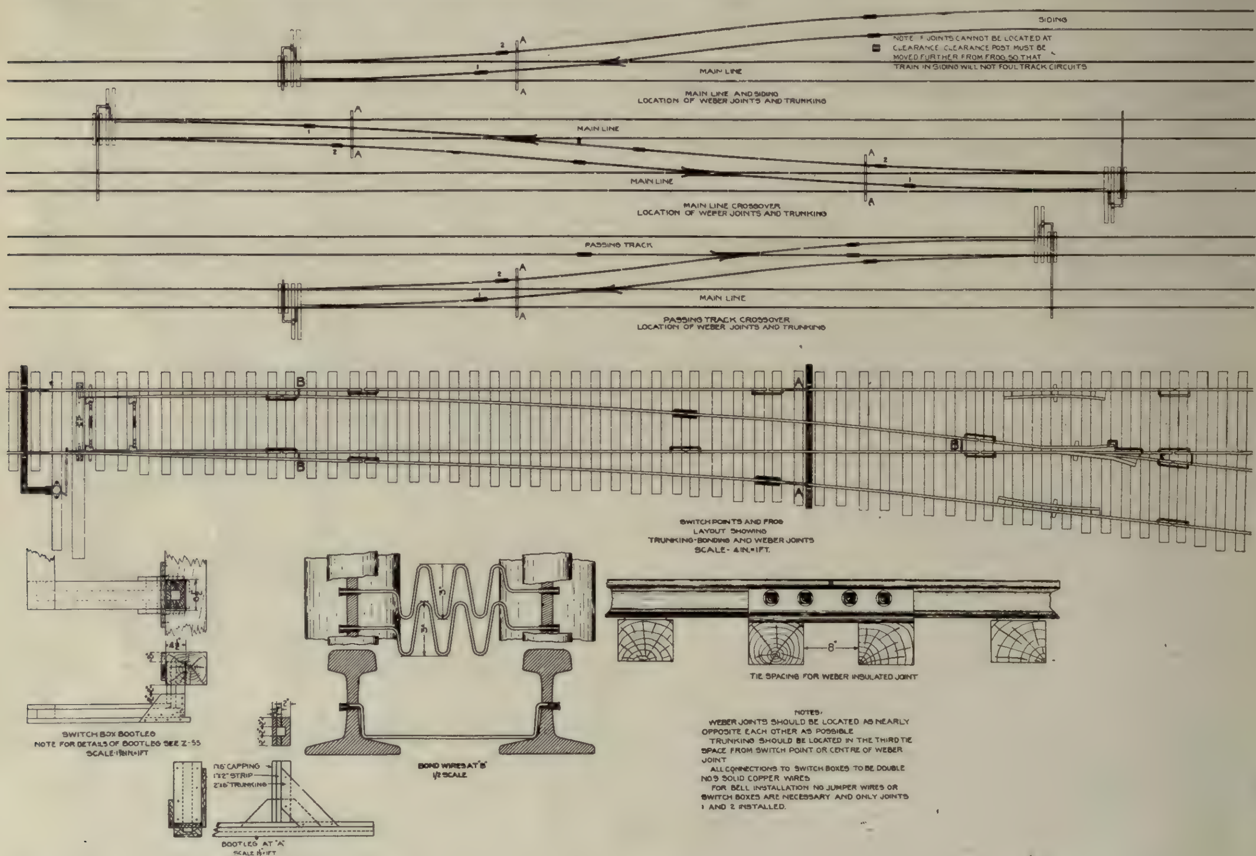
Figs. 419 and 420 show how a "cut section" may be introduced into a polarized track circuit. Here a polarized relay is used at the end of the right-hand section to reverse the polarity of the circuit for the left-hand section. This relay acts exactly as above described with relation to the pole changer. Its polarized armature fingers are made to take the place of a mechanical pole changer, thus repeating the action of the mechanical pole changer to the left-hand section. Fig. 419 shows the normal condition of the two circuits; Fig. 420, their condition when the mechanical pole changer is reversed. It should be noted that the neutral point at the cut section relay breaks and shunts the circuit in the rear just as in an ordinary cut section (Figs. 409-411) to transmit the shunting effects of a train in the right-hand section to the other.

Where switches occur in a track circuit special means must be employed to prevent short circuiting through the switch rods, and leakage to the turnout rails. Fig. 431 shows the simplest method of accomplishing this. Wedges are placed under the normally open point; these wedges are not in contact with the main track rail or the tie plates. They raise the switch point off the tie plates when it is open, but allow it to rest on them

when closed. Two insulated joints are installed in the turnout tracks, one just behind the heel of the frog and the other at the end of the stock rail. This method is objectionable, for any metallic substance lodging between the wedges and tie plates will cause a short circuit.

Another method is shown in Fig. 432. One rail is cut out of the circuit and a "jumper" used to carry the current around. The objection to this is that the dead rail might break and no protection be afforded. Also it requires two insulated joints in the main track, which is undesirable (because insulated joints in main track are somewhat expensive to maintain), and should be avoided when possible.

The most usual method is shown in Fig. 433. Here the switch rods, A, are insulated and the insulated rail joints differently arranged. One is placed at C as above; another at B in switch rail between main track rails, and two others, D and E, at the fouling point of the turnout. The switch points are bonded to the stock rails to insure shunting by a pair of wheels on any part of the track. For the same reason the switch, however, occurs in the siding, and this is merely shunted in as far as the main line fouling point. Two wires are used for the jumper so as to give protection should one break. These are soldered to separate bond wires at a convenient joint (Detail A), because if they were tapped into the main track rail at separate points and the rail should break between them, there would be no protection against this broken rail. A detail of the frog bonding is also shown. This guards against a broken frog to a certain extent. Protection against an open switch is secured through the switch instrument or "switch box" shown in enlarged detail. The lever, moved by the rod attached to the normally closed point of the switch, brings the upper set of springs into contact with a similar set below them (not shown) when the point is open ¼ inch or more. The upper set of springs are connected by two wires to one rail of the main track, and the lower set to the other rail, as shown. When the two sets of springs come into contact the result is the same as the presence of a train, namely, a short circuit. Four upper and four lower springs are used in



Figs. 479-483. Location of Insulated Joints and Trunking for Siding, Main Line Crossover and Passing Track Crossover. Atchison, Topeka & Santa Fe.

upper main line rail is connected to the lower turnout rail by the "jumper," F-G. This insures a shunt should a pair of wheels stand anywhere within the fouling point. It is desirable to have this jumper connect at the point G, midway between the insulated joints, to insure maximum amount of live track in case of a broken rail between C and E. If this "jumper" were not used and the insulated joint, C, on the turnout dispensed with, both turnout rails would be of the same polarity and no shunt would be effected. The joints, B and C, should be opposite each other in order to avoid a dead section of track between them.

Fig. 434 shows a method of guarding against a broken wire or rail within the fouling distance on the turnout. Here an insulated joint is placed in the main track near the switch, and a jumper run from each side of it to the fouling section of the side track rail. This puts the turnout rails in series with the main track and a broken wire or rail would open the circuit. No provision is made for similar protection of the inner turnout rails, however. In Fig. 435 is shown how the above protection is applied to a siding crossover. Fig. 436 shows the same applied to a main line crossover.

All the above methods of running track circuit through switches show no protection against an open switch. Fig. 475 shows how such protection is usually provided. The wiring of the track is the same as shown in Fig. 433. An additional multiple, to guard against failure of any one pair and to provide a low resistance circuit.

Fig. 437 shows a slightly different method of arrangement, with the switch box shown diagrammatically. The track circuit is transposed and the contact springs shunt the circuit as above, but around the insulated joint instead of across the track. In this figure is also shown a switch box worked by a siding derail which shunts the main track rails when the derail is closed. The main track is shunted rather than the siding, because a broken wire or rail in the siding would render the shunt inoperative.

Fig. 438 illustrates a method of switch protection which is somewhat elaborate. Under normal conditions current flows from battery through upper rail to insulated joint, thence through jumper, upper pair of switch box contacts, through two middle right-hand switch box binding posts, through jumper, outside siding rail, through derail switch box in same manner as first switch box, to upper main track rail, through relay, back on lower main track rail to battery. When either switch or derail is reversed the run around jumper circuit is opened and the relay shunted by the switch box. These switch boxes are provided with two normally closed and two normally open contacts instead of four normally open, as in previous examples. In this figure a control circuit is shown carried through one pair of closed contacts in each box. This circuit would be

broken with either switch or derail reversed. This represents a line wire controlling the signal and is provided as an additional precaution. A switch indicator is also shown at the derail.

Fig. 439 shows two switches close together. Here the track circuit is transposed by means of a run around jumper between the switches. Current passes from upper rail right-hand side, through jumper to lower rail left-hand side and from upper rail left-hand side through frog, switch point, to lower rail through bond wires, also in parallel in a similar manner through the other frog and switch point. The switch boxes shunt the circuit. No switch boxes are used at the derail and siding switch, because these are controlled mechanically from the main line switches. Many roads, however, use switch boxes even at both ends of pipe connected or plunger locked switches and derails as an extra precaution. Fig. 440 shows a similar arrangement as applied to a crossing with a single slip switch and crossover between two main tracks. All the switch boxes must shunt both main tracks because with any switch open a train might foul both tracks.

Fig. 441 illustrates what is perhaps the highest development of crossover protection. Here the rails of the crossover are made into a separate track circuit whose relay, when de-energized, shunts both main line circuits. The relay may also be made to break one or more signal control circuits, as was done by switch boxes in Fig. 438. The switch box wiring is the same as that illustrated in Fig. 475, except that one pair of springs in each box is normally closed and breaks the crossover track circuit with either switch open. It is obvious that a broken crossover rail will cause the shunting of both main line circuits, also that a single engine or car standing on the crossover, with both switches closed, would produce the same result.

Figs. 472-474 show the New York Central standard circuits for switch protection. They are similar to Fig. 475.

Where one track crosses another at grade means must be provided to carry the track circuits through or around the crossing frogs. Figs. 468-471, inclusive, illustrates how this may be done. In Fig. 468 the horizontal track circuit goes through and the other is carried around the frogs by jumpers. In Fig. 469 there is only one circuit, which is transposed at the frog. Fig. 470 is used instead of Fig. 468 when the crossing is at or near a right angle and insulation cannot easily be placed in the frog rails. Fig. 471 is a development of Fig. 470, and is the most usual method; nevertheless, in order to guard against broken rails or frogs, it is desirable to have as little dead track as possible.

Fig. 476 shows how single rail circuits (see Figs. 414-416) may be used where there is foreign current that might interfere with a two-rail circuit. The cross bonding beyond the track circuit does away with any difference of potential which might otherwise exist between the rails, and the foreign current is carried past through the lower rail, which is made common to all the track circuits. Fig. 477 shows another method of accomplishing the same results, which may be used with a short isolated circuit. While allowing both rails to be used for a track circuit, the cross bonds are installed as above, and foreign current is carried past through a jumper connecting these bonds. In Fig. 478 is shown an electric railroad crossing two tracks of a steam road. The track circuits of the steam road are carried around as in Fig. 471, but to avoid leakage as far as possible the trolley track is cross bonded on each side of the frogs to prevent any difference of potential that might otherwise exist between the rails, and all members of the frogs are bonded together and to the heavy central jumper connecting the cross bonds.

CONTROL CIRCUITS

NORMAL CLEAR. LINE CONTROL.

In Fig. 484, if a car or train occupies the track between the insulated joints, J, J, it shunts the relay R. This allows its armature to drop, opening the local circuit, de-energizing the magnet, which, when energized, holds the signal in the clear position.

In Fig. 485 the home arms are controlled as shown in Fig.

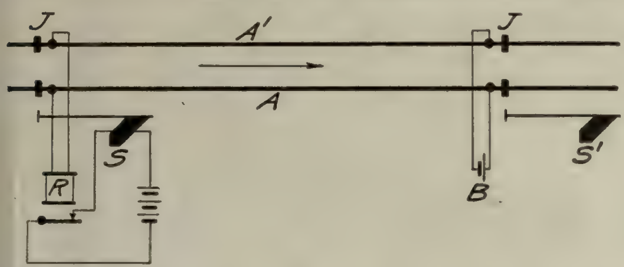


Fig. 484. Arrangement of Track Circuit and Connections for Normal Clear Automatic Block Signals.

484. Each home arm, when moved, moves its two circuit controllers; one to control the circuit to its distant signal, one block in the rear, and the other to control the distant arm on its own post. For control of the distant one block back, current flows from the main battery through the second contact on the track relay, to the circuit controller, and thence over the line to and through one of the controllers at the signal in the rear and to the electro-magnet there controlling the distant arm; thence back over the common return wire. The control by a home signal of the distant arm on its own post (which primarily is controlled by the home arm one block in advance), is to avoid an apparently inconsistent indication when the home arm is at stop, while the distant, so far as its own section is concerned, might be clear. The home arm can put the distant to caution, but cannot clear it, except when the home arm in advance is clear. Switch indicators are shown connected in series, operated by contacts on track relays.

Fig. 486 is the same as Fig. 485, but with each home signal controlled by the track relay of two blocks in advance, instead of only one. Thus the home signal at the extreme left of the drawing is controlled (1) by its own track relay, and (2) by the track relay of the block in advance.

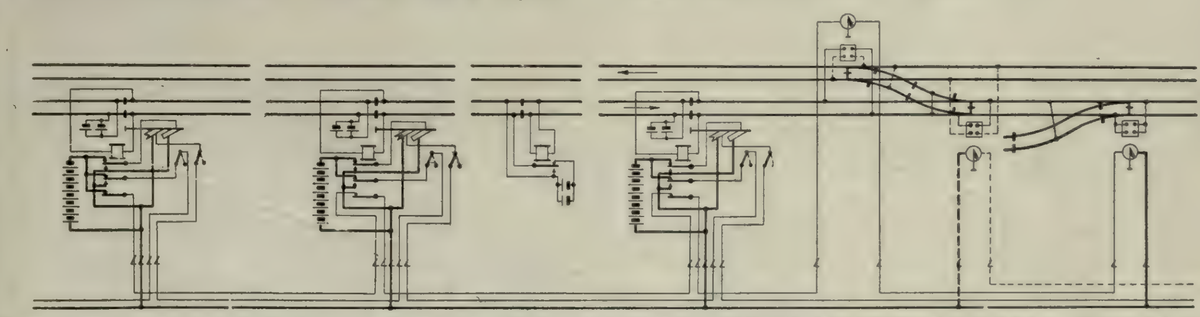


Fig. 485. Arrangement of Circuits for Normal Clear Automatic Signals; Line-Wire Control for Distant Signal.

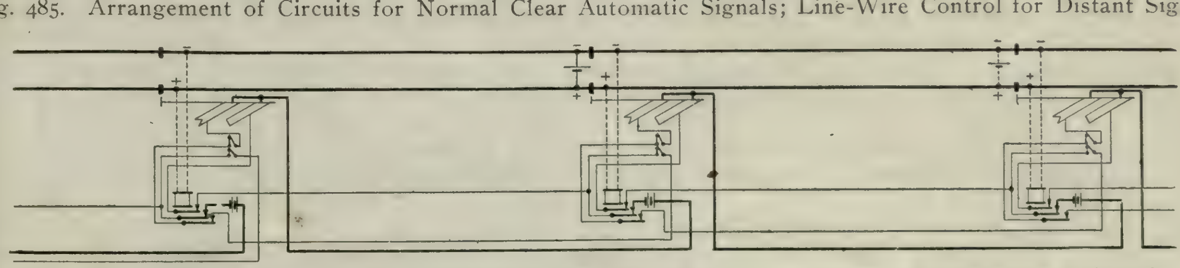


Fig. 486. Normal Clear, Line-Wire Distant Control and Full-Block Overlap. Pennsylvania Railroad.

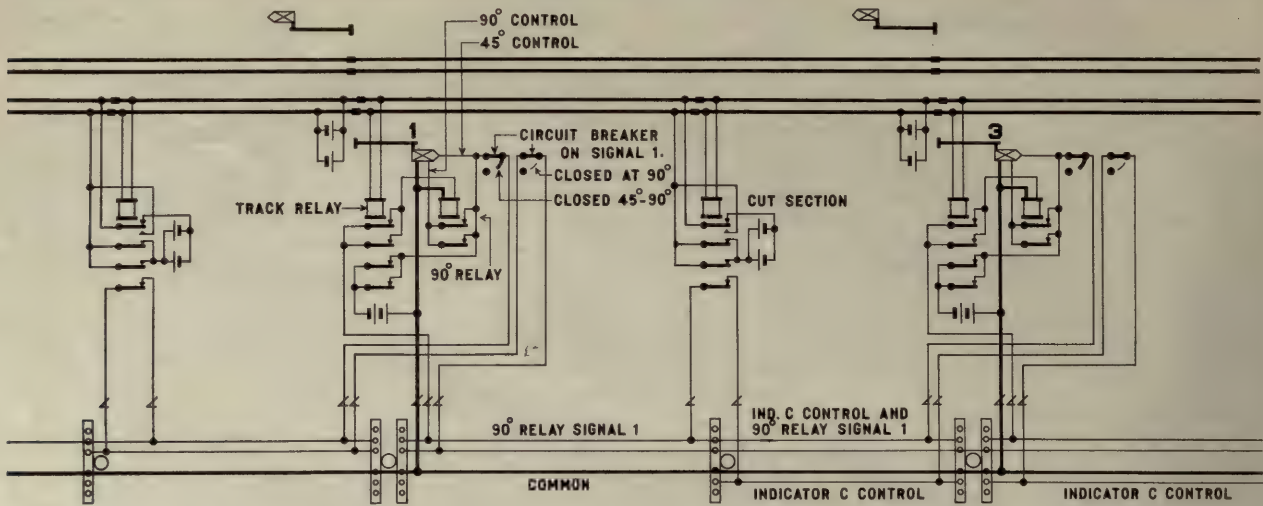


Fig. 487. Circuits for Normal Clear, Three-Position Signals. Northern Pacific Railroad. General Railway Signal Company.

Fig. 487 shows circuits typical of double-track installation on the Northern Pacific. The signals are G. R. S. Model "2A," three position, upper quadrant, low voltage d. c. control. The track circuits are relayed through cut sections, being shunted on the opening of any switch in the given sections by the switch circuit controller. This permits the use of a local circuit for the control of the 45-deg. position of the signal. The signal and a stop indication at the signal for the block in which the switch is located.

NORMAL CLEAR—POLARIZED LINE CONTROL.

Fig. 488 shows diagrammatically the circuits used in connection with an installation of normal clear, three-position, upper quadrant signals on a single-track division of the

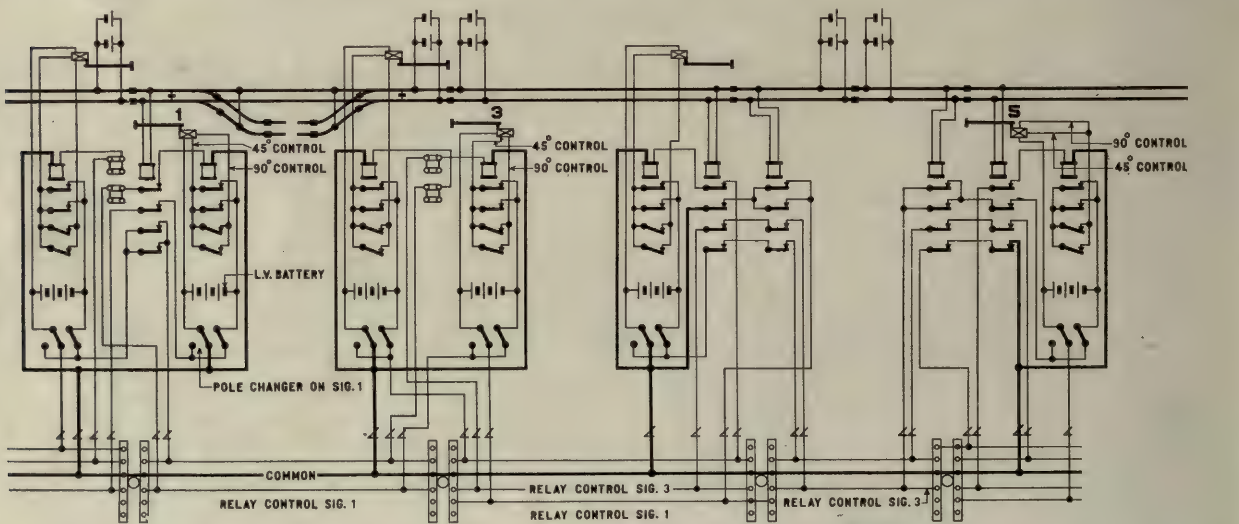


Fig. 488. Circuits for Normal Clear, Three-Position Signals. Polarized Line Control. Northern Pacific Railroad. General Railway Signal Company.

circuit for the control of the 90-deg. position, in every case, is broken through the circuit breaker on the signal in advance, energy being obtained from the 45-deg. control wire of that signal. The control for the indicators is carried far enough back so that warning is given at the switch when a train is approaching the second signal in the rear; if the switch is open, the train is given a caution indication at that Northern Pacific. The signals are G. R. S. Model "2A," low voltage d. c. control.

In this circuit, the signal is controlled by a polarized relay, the 45-deg. control being taken through the neutral contacts only while the 90-deg. control is taken through both the neutral and polarized contacts. The energy for this line relay, in every instance, is taken from the battery of the signal in

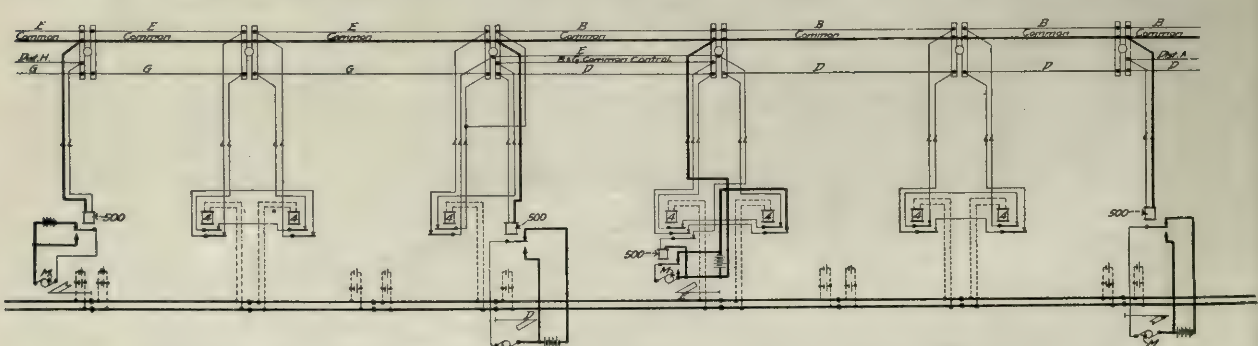


Fig. 489. Circuits for Normal Clear Automatic Signals on Single Track; Maximum Distance for One Pair of Staggered Signals. Southern Pacific.

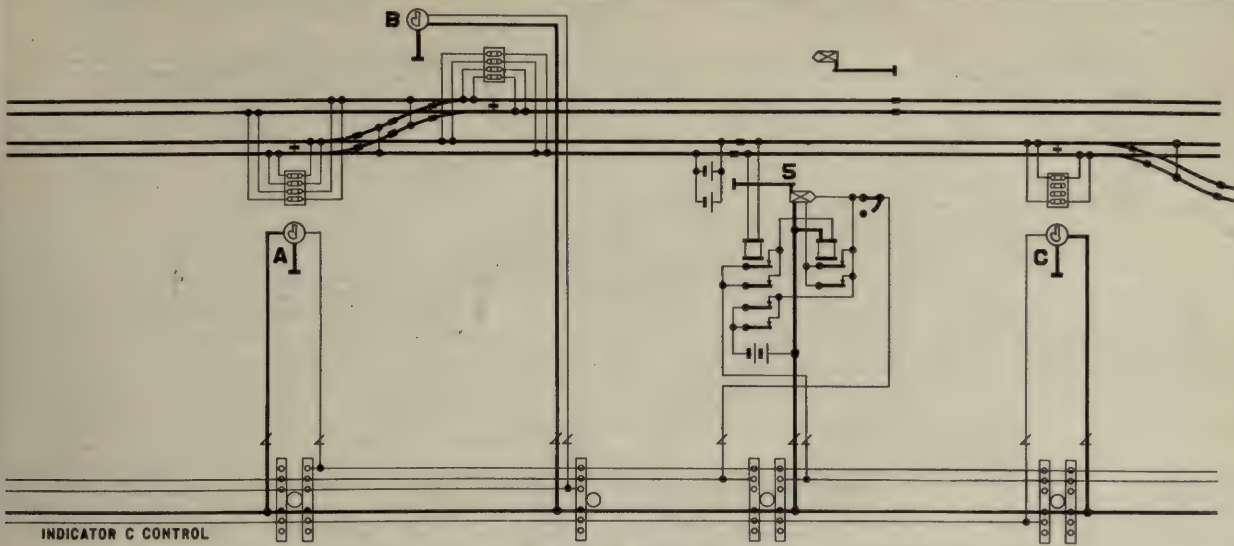


Fig. 487. Continued from Fig. 487 on Opposite Page.

advance through pole changer contacts operated by the mechanism of that signal, the arrangement being such that the positive side of the battery is connected to the line when the signal is in the 90-deg. position, and the negative to the line when the signal is in the 45-deg. position. The relay is further controlled through the front contacts of all track

When the characteristics of the signal control are such that nothing is to be gained by operating through three positions (see signal 5, Fig. 488), only two indications, the 0 and 90-deg., are given. This is accomplished by joining the 45 and 90-deg. control wires and taking them in series through the neutral and polarized contacts of the controlling line relay.

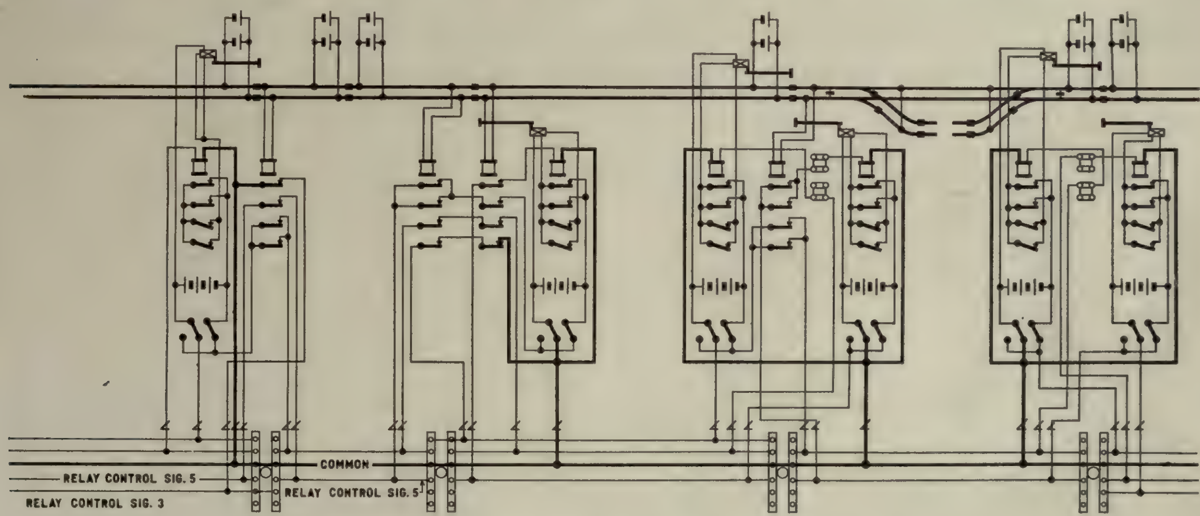


Fig. 488. Continued from Fig. 488 on Opposite Page.

relays and through normally closed contacts of all switches within the section governed by the signal in question. The signal is thus controlled in the 90-deg. position through the next signal in advance at 45 or 90 deg. and in the 45-deg. position through the track relays of the sections within the control of the signal in question.

It will be seen that on account of the type of overlap used, two trains running in opposite directions between stations cannot come closer together than a block of 3,000 ft. without encountering a stop signal, and will, in practically every instance, have been prepared for such stop signal by receiving a caution indication from the previous signal.

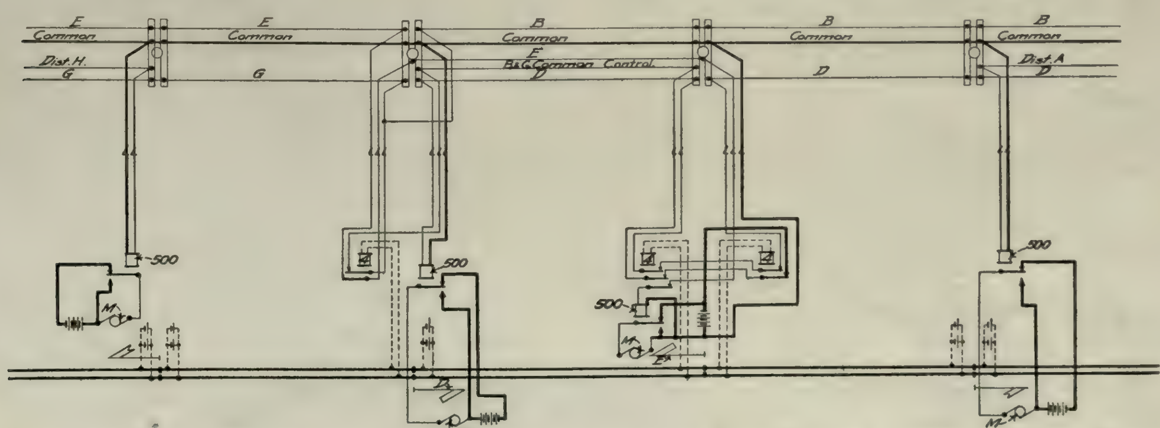


Fig. 490. Circuits for Normal Clear Automatic Signals on Single Track between Stations; Minimum Distance for Staggered Signals. Southern Pacific.

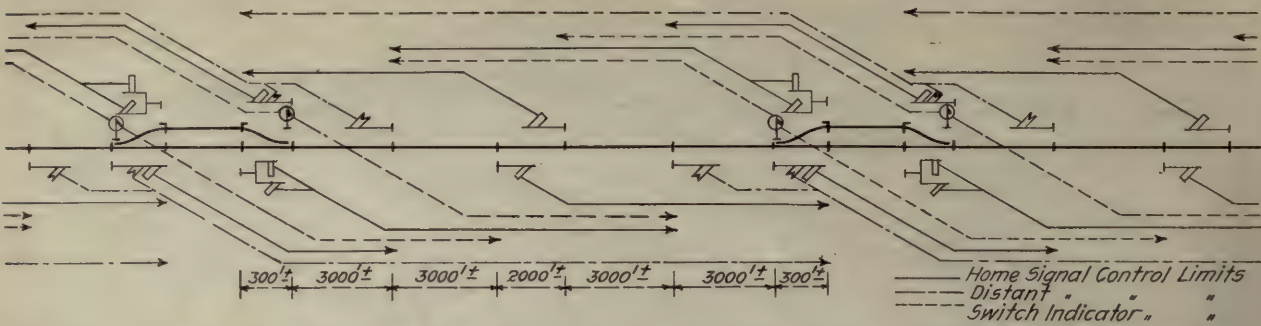


Fig. 491. Diagram of Clear Automatic Signals for Single Track Showing Control Limits of Apparatus, as Used on the Ulster & Delaware. The Union Switch & Signal Company.

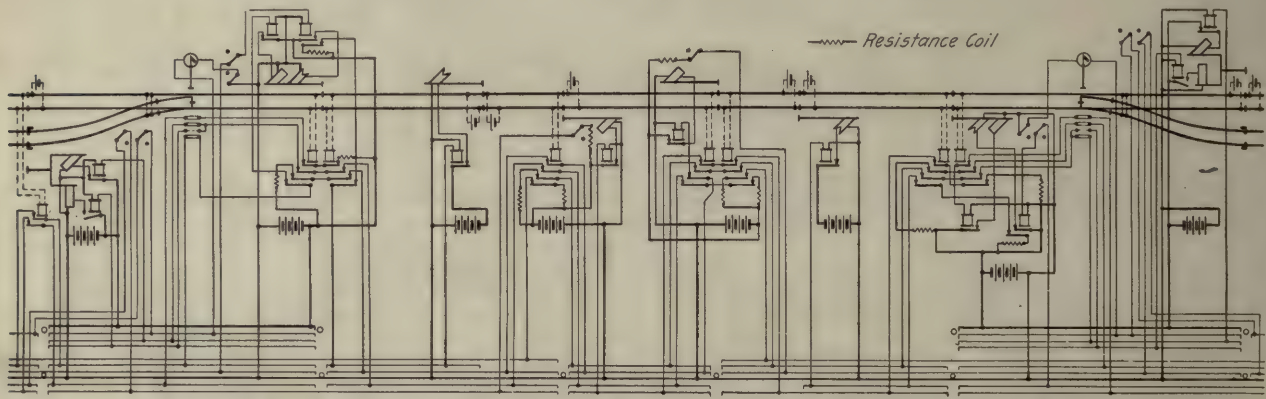


Fig. 492. Diagram of Typical Circuits for Signals Shown in Fig. 491. The Union Switch & Signal Company.

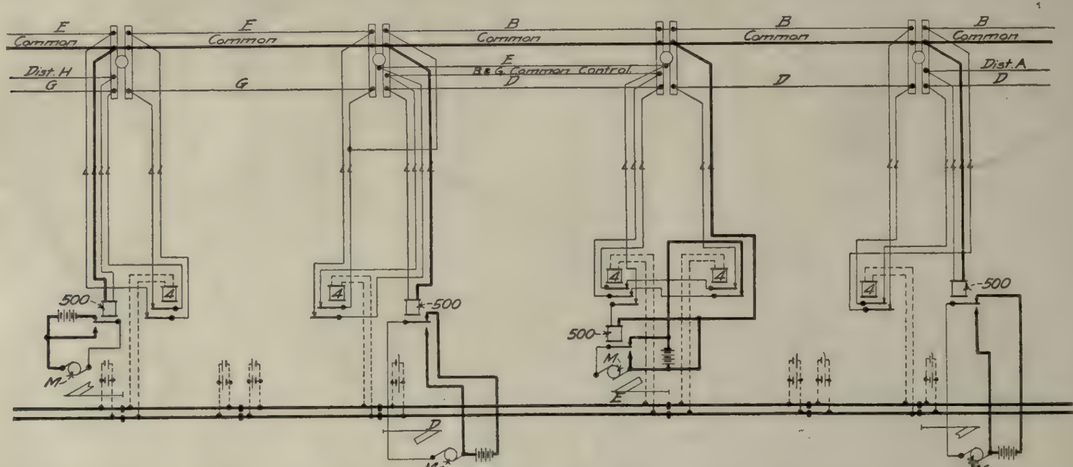


Fig. 493. Circuits for Normal Clear Automatic Signals on Single Track, Alternative Arrangement, Where Section between First Staggered Signal and Station Distant Signal is too Great for One Track Circuit. Southern Pacific.

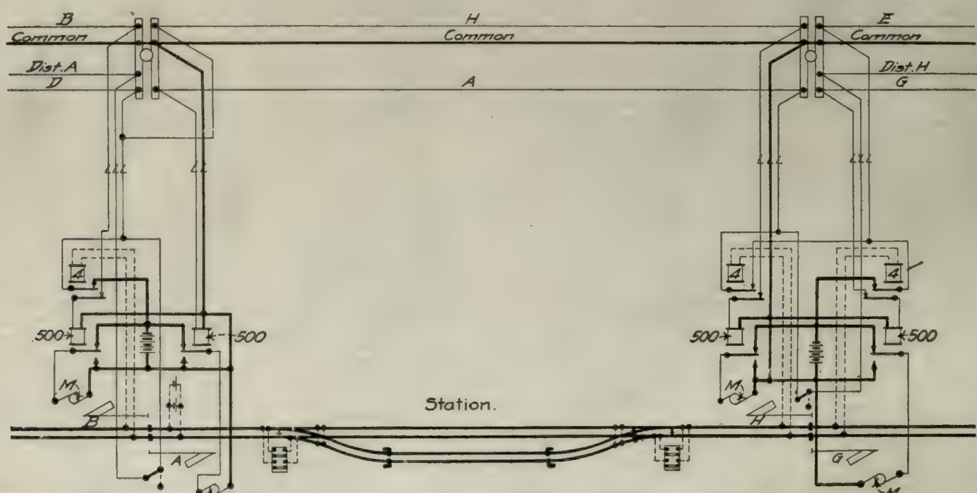


Fig. 494. Circuits for Normal Clear Automatic Signals at Stations on Single Track. Southern Pacific.

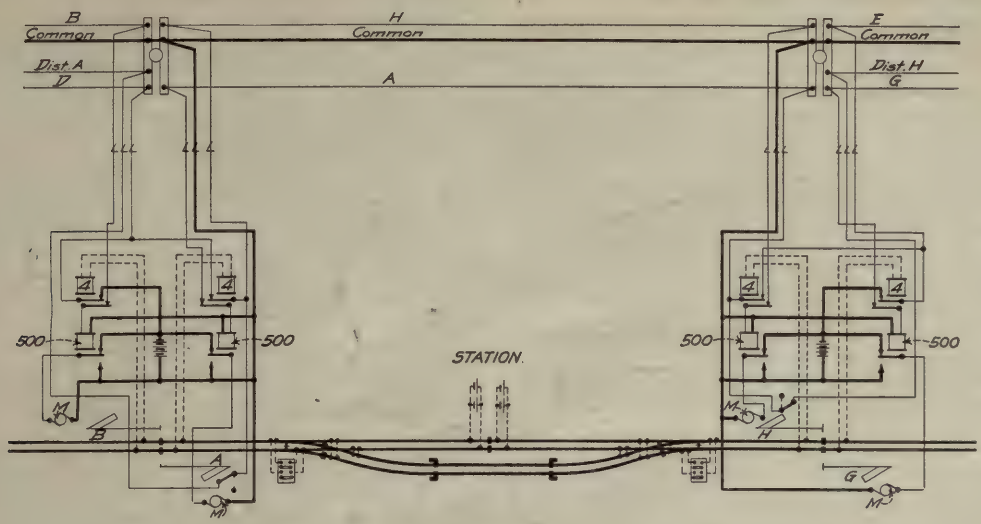


Fig. 495. Circuits for Normal Clear Automatic Signals on Single Track, to be Used Instead of Those Shown in Fig. 494, Where Section is Too Long to be Included in One Track Circuit. Southern Pacific.

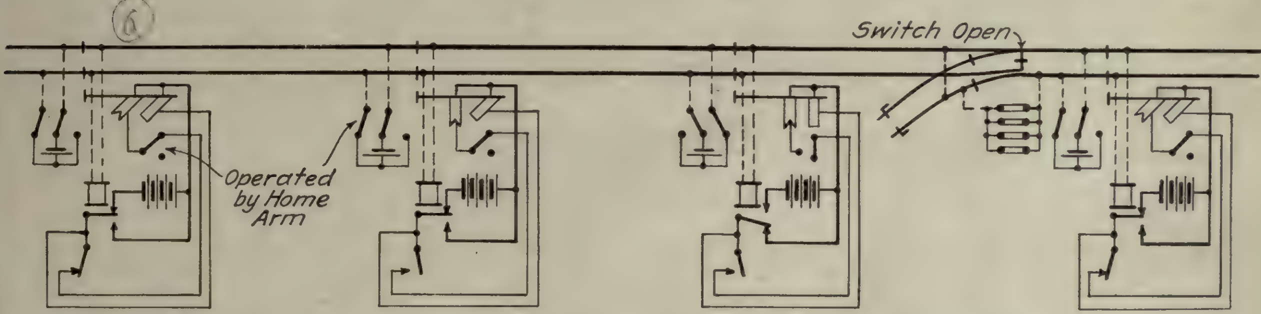


Fig. 496. Arrangement of Circuits for Normal Clear System; Distant Signals Controlled by Polarized Track Circuit. The Union Switch & Signal Company.

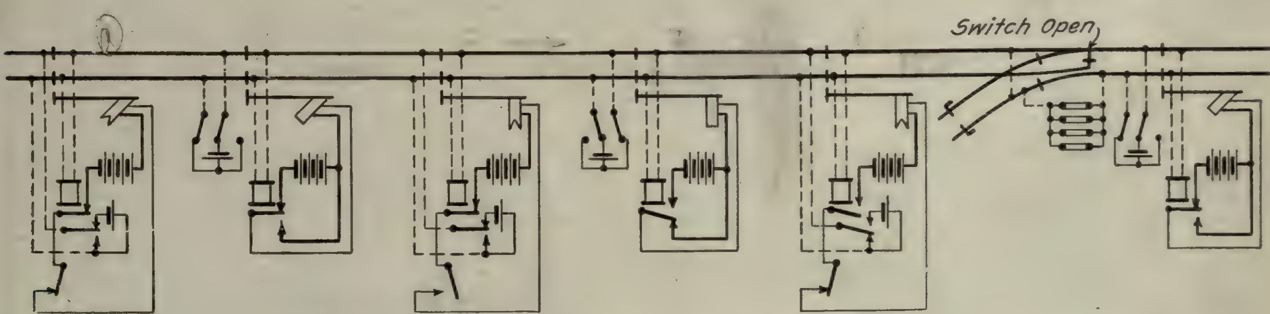


Fig. 497. Circuits for Normal Clear System, Polarized Track Circuits Controlling Distant Signals on Separate Posts. The Union Switch & Signal Company.

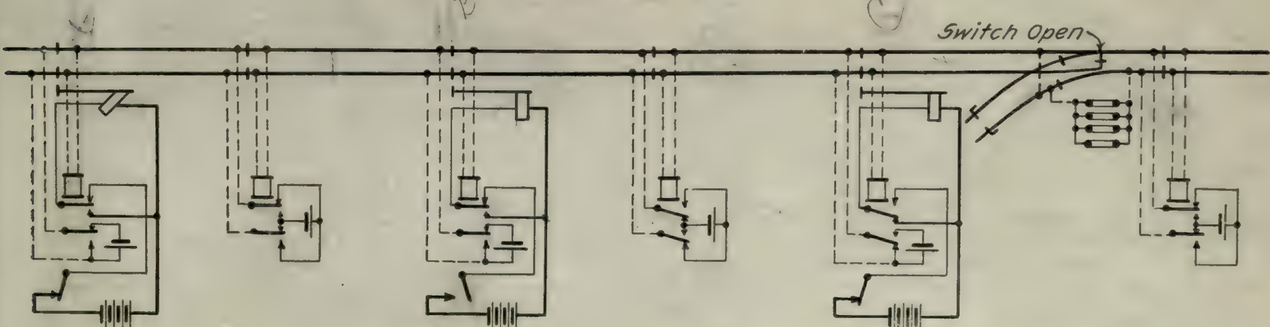


Fig. 498. Circuits for Normal Clear System with Overlap, No Distant Signals; Polarized Track Circuit Controlling Home Signals. The Union Switch & Signal Company.

NORMAL CLEAR—POLARIZED "WIRELESS" CONTROL.

Figs. 496-497-498 show how the polarity of a track circuit is used by the Union Switch & Signal Co. in the control of signals.

In Fig. 496 the home and distant signals are on the same post. The home signal is controlled directly by contacts on the neutral armature of the track relay. The distant signal circuit is passed through this contact on the neutral armature and also through the one on the polarized armature. The distant signal is, therefore, put in the caution position, either by a shunting of the track circuit or by the home signal in advance, which reverses the polarity of the track circuit by means of the pole changer; it is also put to caution whenever the home signal on the same post goes to stop, by means of a circuit controller operated by the home arm.

The presence of a train in the section de-energizes the track relay and both arms assume the horizontal position. This is also done by the opening of a switch as shown near the right of the figure, the track circuit being shunted through the contacts in the switch box.

At the signal on the extreme left of Fig. 496 all parts of the apparatus are in their normal position. The relay is energized with current of the right polarity to close its polarized contact, and the circuits for both arms are closed, holding them clear. At the second signal from the left the relay is energized, but with current of the wrong polarity to close the polarized contact. The circuit for the home arm is closed (by the neutral contact), but the circuit for the distant arm is broken at the polarized contact which is open. At the third signal from the left the relay is de-energized, being shunted by the switch box, mentioned above. This opens the circuit for both arms at the relay; the distant circuit is again broken by the circuit controller on the home arm. The pole changer, also operated by the home arm and controlling the current from the track battery, is here reversed, which results in the caution position of the distant arm at the next signal in the rear. At the signal on the extreme right the apparatus is normal.

If the switch should be closed the relay at the next signal in the rear (now open) would be energized, closing both contacts. The home arm clears at once and when clear completes the circuit for the distant arm on the same post; it also operates the pole changer. The pole changer is arranged to "snap" over, so as to allow the relay (at the second signal from the left) to be de-energized for only an instant when the change in polarity takes place. This closes the polarized contact, completing the circuit that clears the distant arm. By using the mechanism shown in Fig. 538 these circuits may be used for a three-position signal. The use of the back contacts on the relays is explained in connection with Fig. 534.

Fig. 497 is a circuit diagram for home and distant signals with polarized track circuits, where the distant signal is not on the same post with a home signal. The distant signal is controlled by the track circuit immediately in advance through a neutral contact of the relay, and by its home signal through the pole changer. The home signal is controlled by both of the track circuits as one is relayed by the other at the distant signal.

Fig. 500 shows a "wireless" track circuit arrangement for automatic block signals.

The distant signal is controlled by a change of polarity in the track circuit acting on a special differential relay with six coils. Four of these are double wound, and the other two act as an ordinary track relay. The local signal battery acts on one set of windings and current from the track circuit on the other, in such a way that when the track circuit is normal the two circuits neutralize each other in two of the coils and act together in the other two. When the track circuit is reversed the coils formerly neutralized are energized and vice versa.

Only three of the coils are shown in the diagram. The relay marked 3 is the ordinary track relay. The armature controlling the distant arm is centrally pivoted between the four double wound coils.

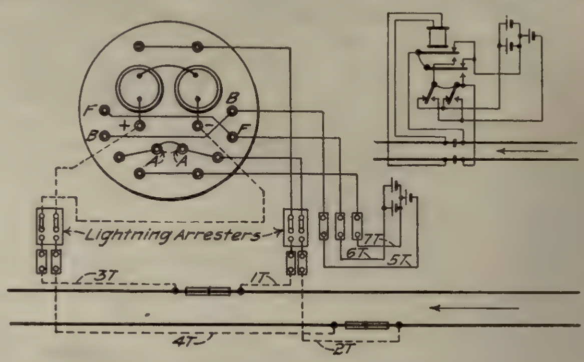


Fig. 499. Circuit Diagram for Polarized Cut Section, Effecting the Change in Polarity by the Use of Two Separate Batteries. Delaware, Lackawanna & Western.

Fig. 499 shows a wiring diagram for a relay box at a polarized cut section. The relay shown is the Union Switch & Signal Co.'s "Universal" type. Reversal of polarity in the second section is accomplished by means of a third cell of battery connected in opposition to the normal cells, as shown in the small diagram. A cell of the alkaline open-circuit type is usually employed, as it is active only for very short periods of time in comparison with an ordinary track battery.

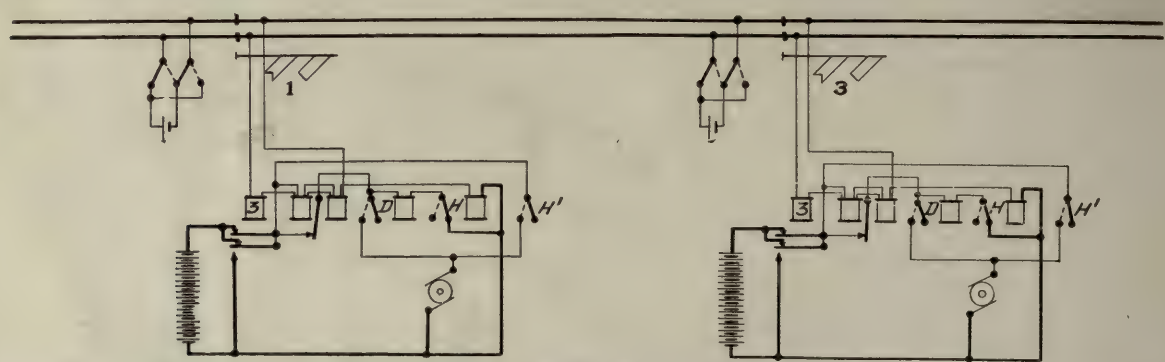


Fig. 500. Arrangement of Circuits for Normal Clear "Wireless" System, Distant Signals Controlled by Polarity of Track Circuits.

Normal clear three-position automatic signals on the Rock

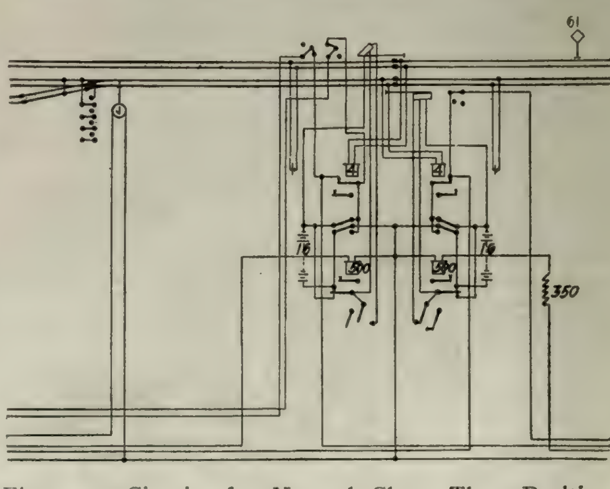


Fig. 501. Circuits for Normal Clear, Three-Position Signals, Batteries Feeding "With Traffic," Home Signals Controlled Through Line Wires and Distant Signals by Polarity of Line Circuits. Rock Island Lines.

Island system are controlled by polarized line circuits (Fig. 501). Track batteries are placed at the entering end of the sections. The local circuit for the first or caution position is controlled by the neutral points of a 500-ohm polarized line relay. This line relay is controlled by a circuit from battery at signal in advance, through a pole changer operated by the second position of the advance signal, points of the track relay for the home section, over the line, to and through the 500-ohm relay to common. The third or clear position of the signal is controlled by the polarized points of this relay. With this system of wiring the positive side of one battery and the negative side of another may both be connected to common. Track circuits are not relayed, but when it is necessary to cut a section the circuit for the 500-ohm relay is carried through the points of the cut section relay. Switch indicators are controlled by circuit breakers on the signal arms and by the contacts on the track relays.

NORMAL DANGER—LINE CONTROL.

Fig. 502 is a diagram of circuits for a "normal danger" system designed by the Hall Signal Co., using a differential relay for clearing purposes.

Consider a train to be entering the first block (at home signal 1). Current passes from the battery at home signal 5, over line wire 3, through a normally closed contact in the switch box, to and through the upper front contact of the track relay signal 3, circuit controller C, front contact on differential relay (now closed) distant clutch, to common. This clears signal 5 in the same manner as already explained for signal 3, but when the 1,000-ohm relay (at signal 5) is shunted the differential relay will not at once pick up, because of the resistance of the clutch D (for signal 5 D), which is in series with the eight-ohm winding. However, enough current is now flowing to energize this clutch and clear the distant arm 5 D.

When the train passes signal 3, the track relay at that point is de-energized, opening the circuits through both the home and distant clutches at that point, and thus putting both arms in the horizontal position. The back contact on the track relay now connects wire 5 D direct to common, permitting enough current to flow through the eight-ohm winding of the differential relay at signal 5 to pick up its armature, as already described in connection with the differential relay at signal 3. This serves to clear the next signal in advance of 5 (not shown), which in turn permits distant signal 7 D to be cleared as already described for 5 D.

The switch indicator is controlled by the contact E, operated by home signal 3, and also by a front contact on the track relay at that signal. It will be noted that the use of the 1,000-ohm relay and shunt circuit (through the 100-ohm resistance) permits the same line wire to be used for controlling the distant signal that is used for clearing the home signal in advance of a train.

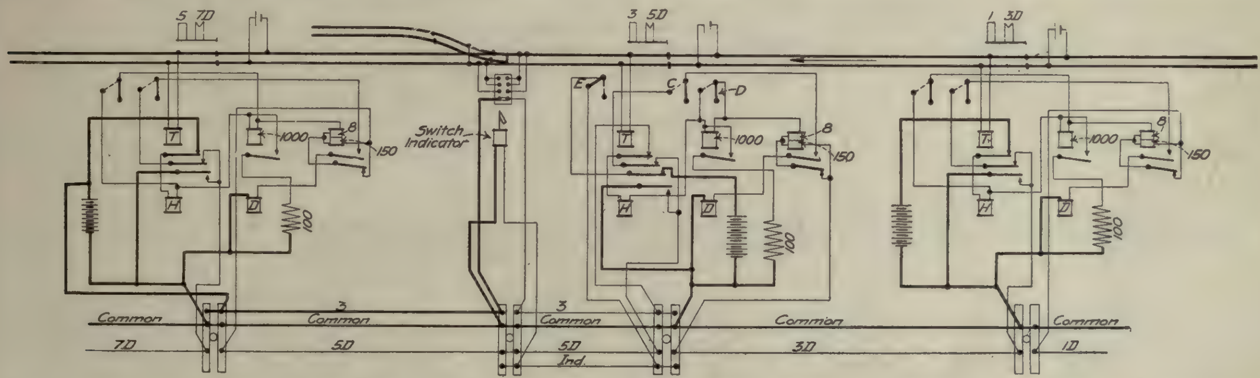


Fig. 502. Signal Control Circuits, Normal Danger Double Track Differential System. Hall Signal Company.

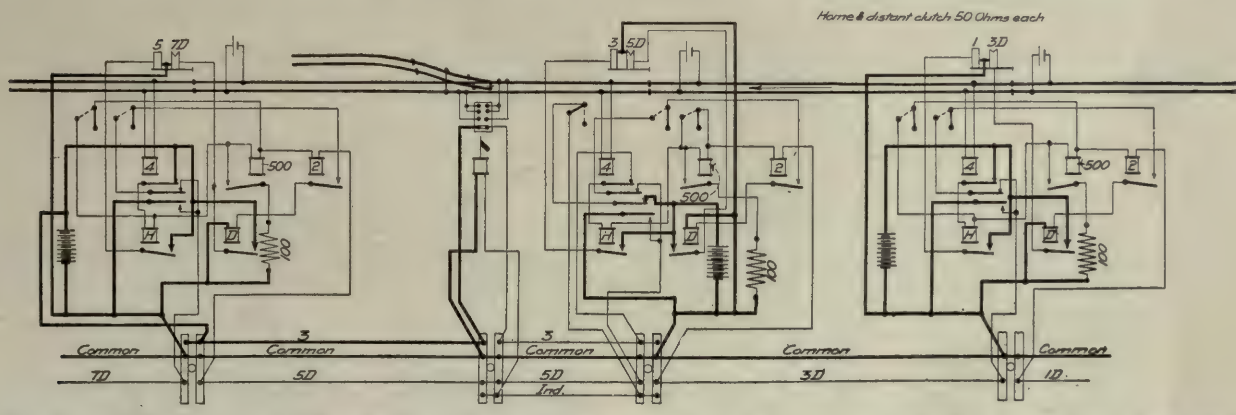


Fig. 503. Signal Control Circuits, Normal Danger Double Track Differential System. Hall Signal Company.

at home signal 3, the home clutch, the coil of the 1,000-ohm relay, the eight-ohm coil of the differential relay, a back contact on the same relay, line wire 3 D, back contact of the track relay at signal 1 (now de-energized) to common. This energizes the 1,000-ohm relay, closing its front contact and thus providing a shunt circuit through the 100-ohm resistance at signal 3 to common; enough current, however, continues to flow through the original circuit to keep the 1,000-ohm relay closed. The home clutch at signal 3 is now energized, causing that arm to clear (for local signal circuit see Fig. 522). Circuit controllers C and D are closed when signal 3 reaches the clear position. D shunts the coil of the 1,000-ohm relay, de-energizing it and reducing the resistance in the circuit through the eight-ohm coil of the differential relay, which allows enough current to pass through it to pick up its armature, opening the back contact which now cuts in the 150-ohm winding. The upper contact on the differential relay also closes and completes a circuit as follows: From battery at home signal 5, through upper front contact on track relay, home clutch, 1,000-ohm relay and eight-ohm coil and back contact of differential relay at signal 5, line wire 5 D, second front contact on track relay at

In Fig. 503, a two-ohm relay is substituted for the 8-150 differential, and a 500-ohm relay in place of the 1,000; otherwise the circuits are the same and also the sequence of operation.

Fig. 504 shows circuits for a normal danger system using clearing relays operated by the track circuits. These clearing relays are compound wound, having two sets of coils each of 16 ohms resistance, so connected to the armature contacts that when the relay is energized one winding is cut out, and when de-energized both windings are connected in multiple.

Consider a train to be entering the first block at signal 1; the compound relay at signal 2 is de-energized and its lower back contact completes a circuit as follows: From battery at signal 3, through line wire (home 2), normally closed contact in switch box, upper front contact on the four-ohm track relay at signal 2, home clutch, back contact (now closed) on the compound relay, 75-ohm resistance to common. This clears the home arm at signal 2, closing the two circuit controllers, shown near the home clutch magnet, and completing a circuit as follows: From the battery at signal 3, through the upper front contact of the four-ohm relay, home clutch H, coil of

relay S, second front contact on the four-ohm relay, line wire (dis. 2), top back contact on the compound relay at signal 2, distant clutch D, circuit controller (now closed), to common. Relay S at signal 3 is now energized, closing a shunt circuit through the 75-ohm resistance to common; this leaves enough current passing through the coil of this relay to keep its armature from releasing. The home clutch at signal 3 is now energized and its arm clears, closing the two circuit controllers and shunting out the coil of relay S, whose armature now drops. With this coil shunted out enough current flows through the distant clutch at signal 2 to energize it and clear the distant arm at that point.

When the train passes signal 2, the four-ohm relay at that point is de-energized, putting both arms in the horizontal position, but closing the line wire (dis. 2) to common through the 75-ohm resistance, by its back contact. This holds the home reliable circuit controllers to the disk mechanism. It also closes, through a back contact, a path for current through one winding of the compound relay to insure its operation in case the back contact on the relay itself should not make good connection.

On the Baltimore & Ohio there is an installation of normal danger automatic signals using a normally closed circuit for clearing signals in advance of a train. A distinguishing feature of this installation is the use of electric lights in the signals, which burn only when a train is approaching. Typical circuits for this installation are shown in Fig. 506.

Fig. 507 shows a normal danger system for single track in a tunnel. Signal 1 controls from B to E. Signal 2 from D to A. Signal 1 clears through back point of relay F; signal 2 through back point of relay I. Circuit for signal 1 is from battery P through front contact 2 of relay I, front contact 2 of relay H,

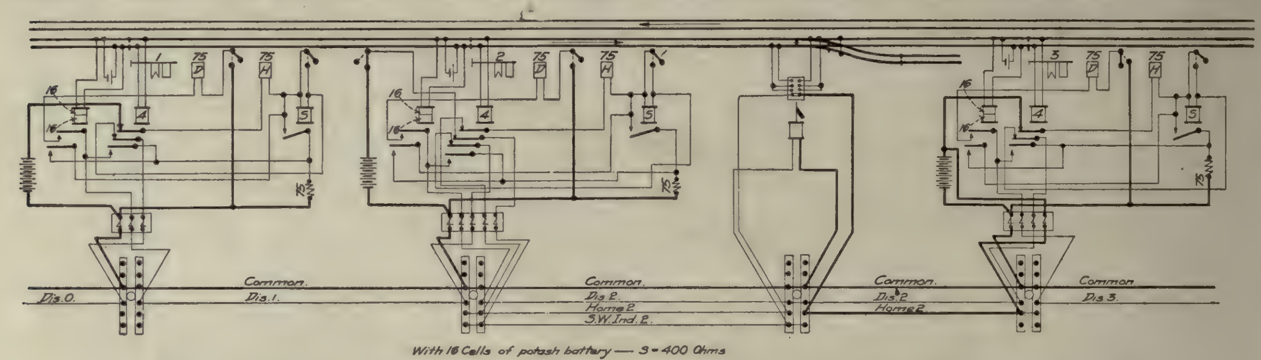


Fig. 504. Arrangement of Circuits for Normal Danger Double Track, with Clearing Relay.

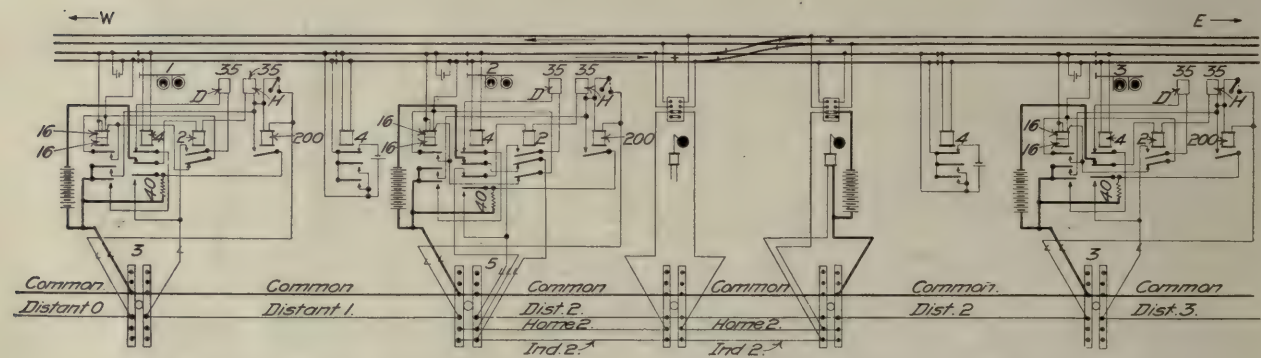


Fig. 505. Circuits for Normal Danger Double Track, Using Enclosed Disk Signal.

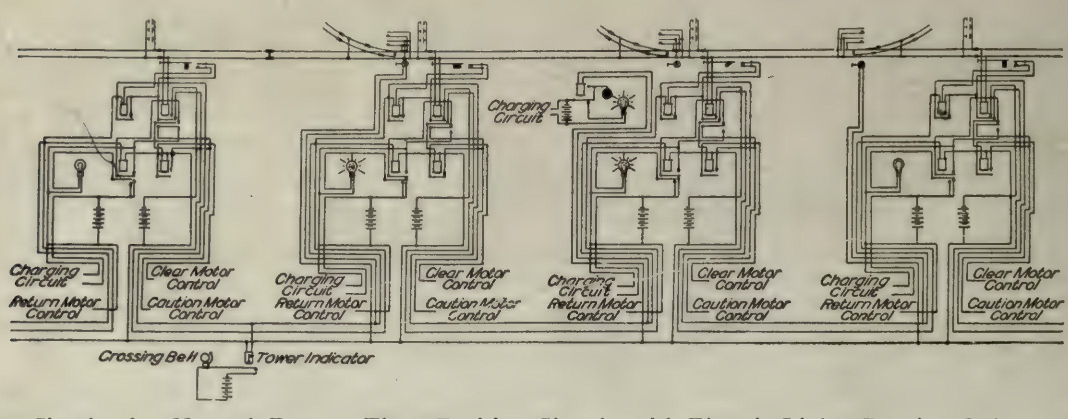


Fig. 506. Circuits for Normal Danger Three-Position Signals, with Electric Lights Burning Only on Approach of Train. Baltimore & Ohio.

signal at 3 clear, in case the compound relay at that point should not be de-energized at once when the train enters its circuit. When the compound relay at 3 drops, the next home signal in advance (not shown) clears, as already explained for signal 3, and permits the distant arm 3 to clear. The switch indicator is controlled in the same manner as in Figs. 502-503.

Fig. 505 shows an arrangement of circuits for the enclosed disk signal similar to that shown in Fig. 504 for the semaphore, the principal difference being the substitution of a two-ohm relay for the circuit controllers attached to the home signal. This relay is used on account of inconvenience in attaching wire through tunnel, signal 1, front contact 1 of relay G, back contact 1 of relay F, to common, and back to battery. The circuit for signal 2 is exactly similar. The wire passing through the tunnel is of small size, so as to be easily broken by the patrolman in case of emergency, thereby holding both signals at the stop position.

Figs. 508-509 show a single track normal danger system with two indicators at each switch, one for each direction. Signals are cleared through back points of the track relay in the section in its rear and the control is overlapped in the usual manner. Control circuits are also broken through circuit break

on first overlap opposing signal in most cases, so that should one of the signals stand clear, the opposing overlap signal could not be cleared. Separate signals are provided for exit from the siding. Indicators in each direction are controlled in parallel with signal governing the block in which they occur, but in opposite direction; "16-16" relays are used in some cases to avoid extending clearing wire to the other end of the track section. Home signals having a distant are controlled through a compound line relay. A train approaching the distant signal closes the back contact of the track relay in the section in the

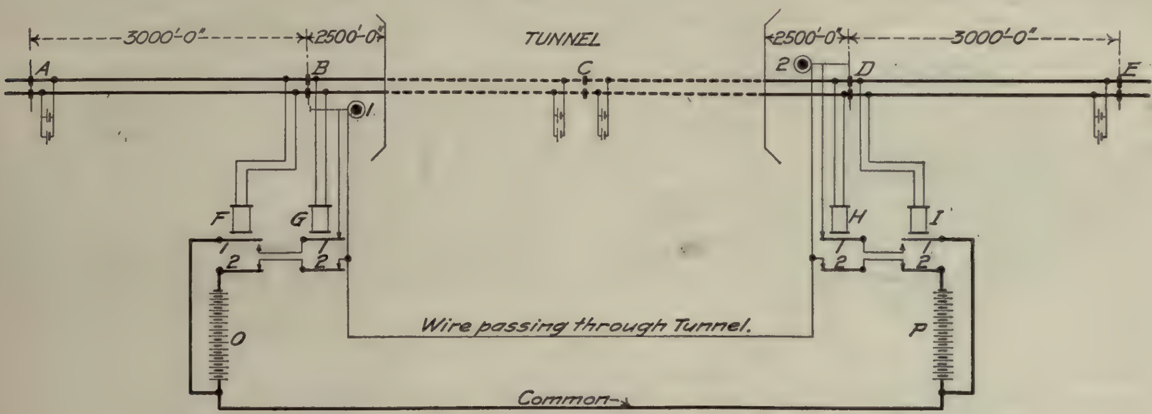


Fig. 507. Arrangement of Circuits for Normal Danger Signals on Single Track for Tunnel Protection. New York Central & Hudson River.

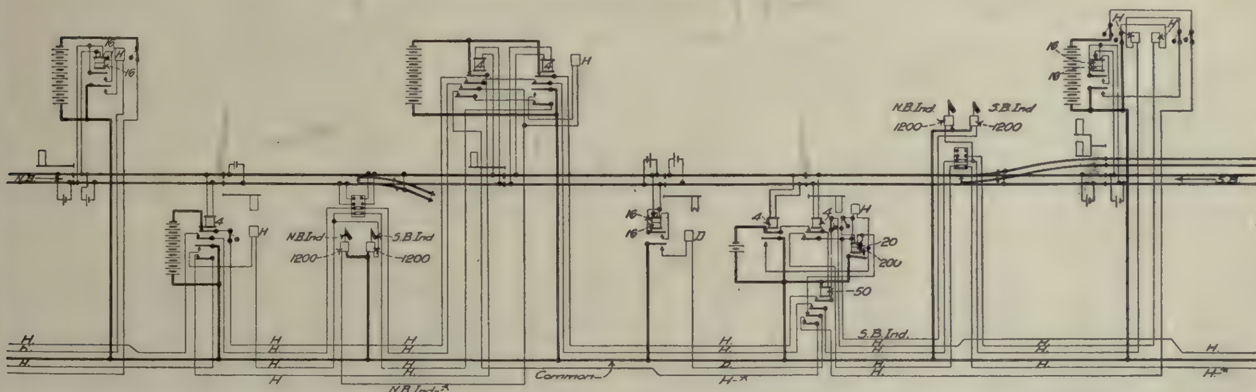


Fig. 508. Circuits for Normal Danger Automatic Signals on Single Track, with Double Switch Indicators. Hall Signal Company.

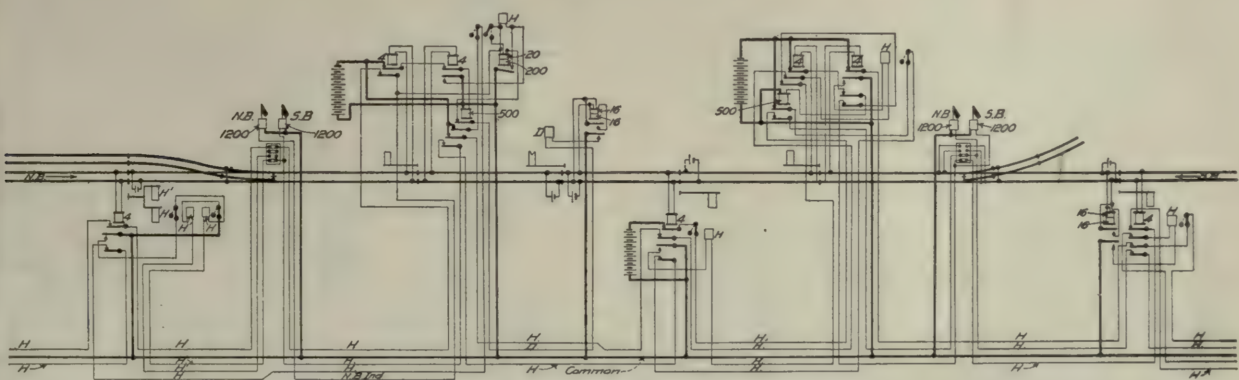
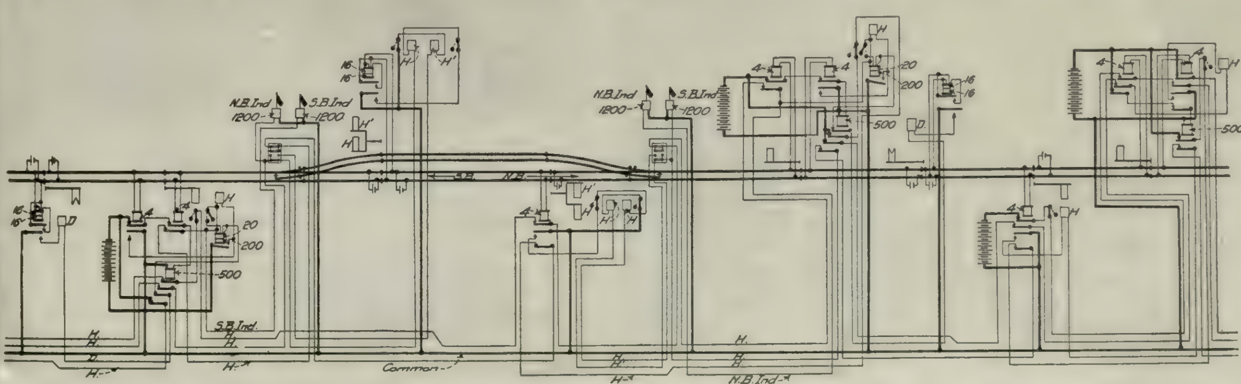


Fig. 509. Circuits for Normal Danger Automatic Signals on Single Track, with Double Switch Indicators.



ig. 510. Circuits for Normal Danger Automatic Signals on Single Track, with Two Indicators at Each Switch.

rear (in this case a 16-16-ohm clearing relay), thereby completing a circuit from common through the distant clutch to line, front contact of repeating relay governed by track relays in advance, 200-ohm winding of compound relay, front contact of track relays in advance of home signal, through line facing switch box and circuit controller on opposing signal to battery at end of overlap section. This permits sufficient current to flow to energize the compound relay, closing the circuit from common through to front contact, home clutch to the home control wire. This clears the home signal and closes the circuit breaker so that the 20 and 200-ohm windings of the compound relay are in parallel, thus reducing the resistance of the circuit sufficiently to permit the distant signal to clear.

Fig. 510 shows the same circuits as Figs. 508-509, except that there is but one turnout.

ABSOLUTE-PERMISSIVE BLOCK SYSTEM.

The General Railway Signal Co. has developed a system of block signaling which is termed the "Absolute-Permissive" block system—"absolute" because it prevents trains from entering a piece of single track occupied by a train moving in the opposite direction, and "permissive" because it permits one or more trains to enter a piece of single track already occupied by a train moving in the same direction. In Fig. 511 starting signals 1, 4, 9 and 12 are shown in the stop position. These may, however, stand normally in the clear position. If, for instance, signal 4 is a normal stop signal, its usual clearing point would be at B. If the distance between B and C is too short the clearing point may be changed to A. However, signal 4 will not clear for a train running in the direction of arrow S. Signal 4 in the 45 deg. position indicates that there is no opposing train nearer than the clearing point for signal 9, but that there is a train running in the direction of arrow R between signals 6 and 8. Signal 4 in the 90 deg. position indicates the same, except that there is no train between signals 6 and 8, but there may be a train running in the direction of arrow R ahead of signal 8. In other words, as soon as a train reaches the clearing section for signal 9 running in the direction of arrow S and signal 9 clears, signals 4, 6 and 8 are held in the stop position. The "head-on" protection is complete and at the same time following trains are allowed to close in to the same extent as in double-track signaling, getting the same signal indications.

If it is desired that the starting signals give a stop and proceed as well as a stop and stay indication, a second arm can be used as shown in dotted lines in Fig. 511. If this arm is used on signal 4, for instance, it will give the 45 deg. indication for an approaching train while the block between C and D is occupied by a train running in the direction of arrow R, but not when this train is running in the direction of arrow S. Signal 4 is thus made to give four indications, viz., stop and stay, stop and proceed, proceed with caution and proceed at speed. As many intermediate signals may be provided as is desired. Each intermediate signal is a unit by itself and such intermediate signals may be located in pairs opposite each other or staggered as local conditions require.

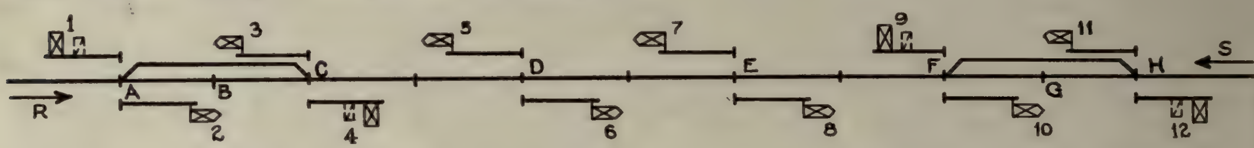


Fig. 511. Absolute Permissive Block Signaling System. General Railway Signal Company.

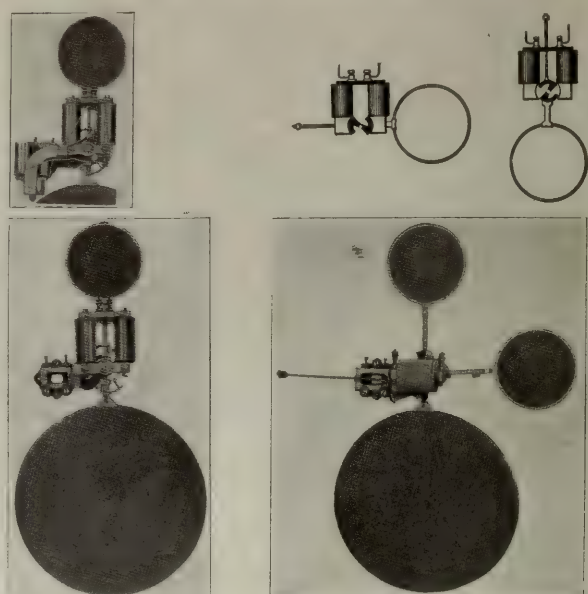
MECHANISMS

HALL DISC SIGNALS.

The outward appearance of a Hall disk signal is shown in Fig. 512. The case is made with wooden front and back and sheet iron sides and top, and is supported on a post of suitable height, or on a bridge, and usually is painted a dark color. The disk, about 18 inches in diameter, made of silk or other light fabric, stretched on a metal ring, or of aluminum, very thin, is fixed to the armature of an electro-magnet in the manner shown in Figs. 513-514-515-516. When the signal magnet is energized the armature holds the disk up, in the position shown at the left of Fig. 513; and an approaching engineman, looking at the glass-covered opening, sees the back of the interior of the case, which is of ground glass, white; this is the clear signal. On the withdrawal of the electric current the disk drops by gravity to a position before the window (the armature and rod turning on the axis as shown), thus displaying a red, or stop, signal.

The enclosed disk is usually mounted on the top of a post or pillar, as before stated. When home and distant signals are used, the cases are arranged as shown in Fig. 512. The upper signal has a red disk, and is the home signal, while the lower one has a green or yellow disk, and is the distant signal for the block section next beyond. Fig. 515 illustrates the Hall disk mechanism with "hold clear" attachment. This consists of an additional set of magnets of high resistance, as shown. The Z rotary armature carries on an arm a second flat armature for the "hold clear" coils. A circuit breaker controls the circuits for the two sets of coils so that when the signal is at stop they are in parallel; when at clear they are in series. Thus the signal is held clear on a low current consumption. Fig. 516 shows the Hall disk instrument used by the Chicago & North-Western. This has two separate night indications. The magnet has only one coil instead of two.

Fig. 512. Disk Signals on the Philadelphia & Reading. Hall Signal Company.



Figs. 513-516. Hall Disk Mechanisms.

UNION DISK SIGNALS.

The Union Switch & Signal Co.'s disk signal is shown in Figs. 517-518. In this design the case is of metal (pressed steel). It is made very narrow, leaving room enough only for the disk, and the electro-magnet is contained in a box outside the main case. The joints of the case are calked, making it airtight, so that the disk cannot be affected by moisture. The box containing the magnet is also tight, but can be unlocked by the repairman. The front and rear glasses are of heavy plate fixed in brass rings. The lamp is supported on hinges, so that it can be turned around to be cleaned and filled. The whole case and the parts supported by it are very light, important parts being made of aluminum, and it may be revolved on its bearings.

Fig. 517. Enclosed Disk Signal. Union Switch & Signal Company.

Fig. 518. Enclosed Disk Signal; Two-Colored Night Indication.

Fig. 519. Disk Mechanism for Enclosed Disk Signal. Union Switch & Signal Company.

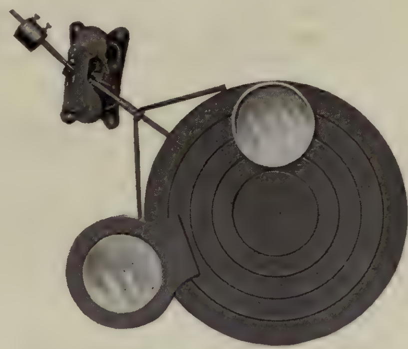


Fig. 520. Disk Mechanism for Showing Two-Colored Night Indications.

In the Union Switch & Signal Co.'s style of signal (Fig. 517) the night signal is a lamp fixed at the back of the disk, outside the case, showing uncolored for clear and illuminating the glass set into the disk for the opposite indication. In the Hall signal the lamp is placed behind the smaller opening near the top of the case, and the upper end of the rod which carries the main disk has fixed to it a small transparent disk, colored to correspond to the color of the day disk.

Fig. 520 shows how the Union disk signal may be made to give two distinct night indications. The glass set into the disk is the stop or caution color; the one projecting from the disk is the clear color.

The metal disk shown above is in the same position that it would be if it were mounted inside the case and indicating stop; the upper glass, which is red, being opposite the lamp. The lamp is supported at the back of the case, and its location is indicated in Fig. 518 by the small white glass disk in the upper part of the large opening. To change the indication of the signal from stop to proceed the metal disk is moved upward and the glass (green), which is attached to its lower part, then comes opposite to the lamp. In the daytime the proceed indication of this signal is shown by the contrast between the color of the outside of the case and that of the back side of the interior, as is done in the older designs of enclosed disk signals.

HALL STYLE "F."

Figs. 523-524 illustrate the Hall Signal Company's style "F" two-arm motor signal mechanism. In the illustrations the left half of the mechanism is shown in the clear position and the right half in the stop position. One-arm mechanisms are exactly like two-arm mechanisms, except that one set of clutch magnets, one thrust rod, thrust piece, clutch lever, etc., are omitted. The cast-iron base supports the motor, clutch coils, pistons of the dash-pot and the frame 14. This frame supports the clutch lever 15. The steel thrust rod 22 is rigidly pinned to the cylinder of the dashpot 6. The base has two pedestals rigidly attached to support the pistons for the dashpots. The piston, in conjunction with the cylinder, forms the guide for the lower end of thrust rod 22. The upper end of this rod runs in a babbitted bearing in the frame. Secured to the thrust rod is the latch support 33, which carries the clearing lever 35, the thrust piece 28 and the latch which engages the lug on the clutch lever 15 to hold the signal clear. The thrust piece carries the latch 31, which engages the lug on clearing lever 35. The large gear wheels are phosphor bronze. They are driven by the steel pinion 3 on the motor and the pinion and shaft 4. The phosphor bronze knife blade contacts of the circuit controller 19, Figs. 523-524, are operated by the circuit controlling rod 9 attached to the escapement crank 11. The escapement crank is controlled by the roller attached to the latch support 33. The front armature of the clutch magnets controls the multiple contacts for the motor circuit. The back armature is attached to the clutch lever 15, which enables the magnets to control the clutch lever. 20 is a multiple circuit controller which is operated in the same manner as 19. Glass cases 37 cover the armature and contacts of the clutch magnets 17 and 18 to

exclude dust. 12 performs the same function as 11, but is left-handed. 10 corresponds in the same way to 9. 33 slides in guides in the frame. 25 is a part of the main frame which carries the bearings for the two gear wheels, 2 and 5. In Figs. 525-526 is shown the guide 30 for the carriage 29 which carries 33. The motor 1 (see Figs. 525-526) is series wound. The fields are laminated iron with but one joint, which is dovetailed, making them further continuous and reducing the magnetic loss on account of joints to a minimum. The armature and commutator are completely enclosed by a brass case over the armature and a glass case over the commutator. The glass case is held in position by two springs bearing on two lugs on the glass. The shaft runs in self-oiling ball bearings.

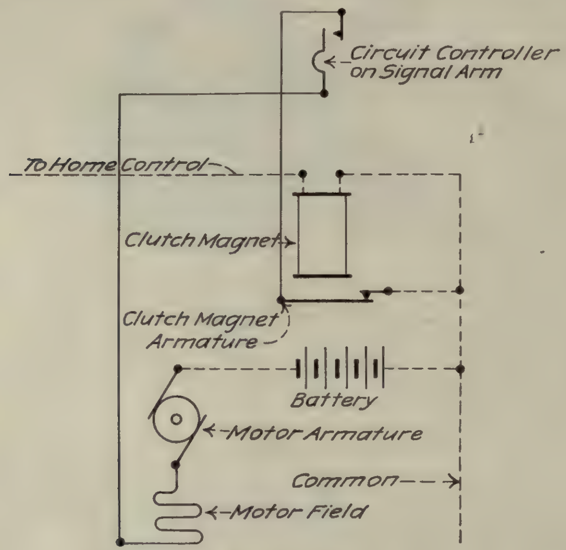


Fig. 521. Local Wiring for Single Arm Style "F" Electric Motor Signal Mechanism.

When the home signal is at stop the circuit controller contacts for the motor are closed and the contacts controlling the distant clutch magnets are opened so that it is impossible for the distant signal to clear until after the home signal has cleared. When the home signal clutch magnet is energized it closes the motor circuit to the contacts on the front armature 17 and at the same time holds the back armature 32, which prevents the clutch lever from moving when pressure is applied to clear the signal. The home circuit being closed, the motor revolves the gears and brings the stud roller 24 under the thrust piece 28 and pushes it up. Since the clutch lever 15 is held by this armature, it prevents the clearing lever 35 from swinging back and by means of the lug on this lever engaging the latch 31 in the thrust piece 28, carries the thrust

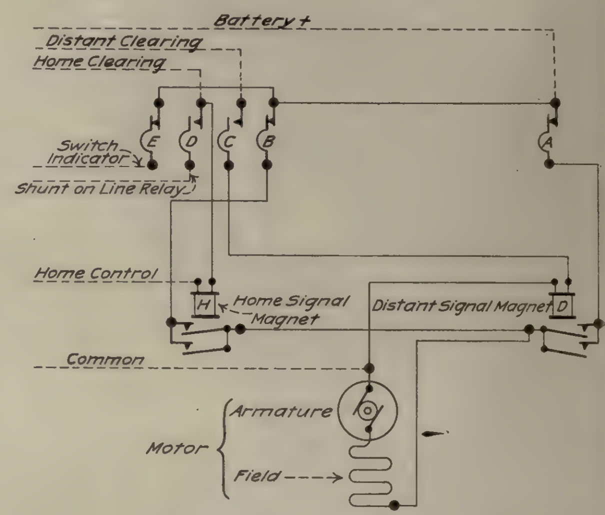
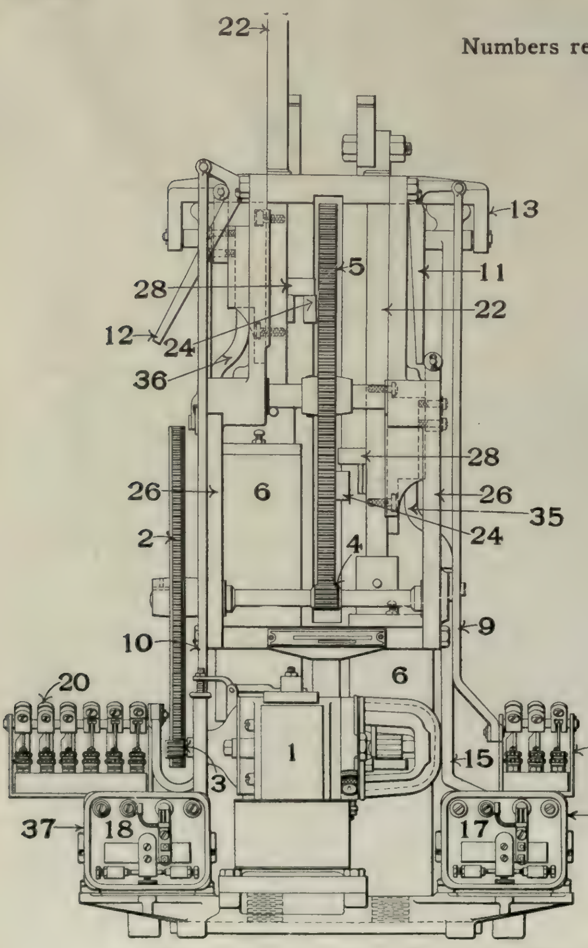
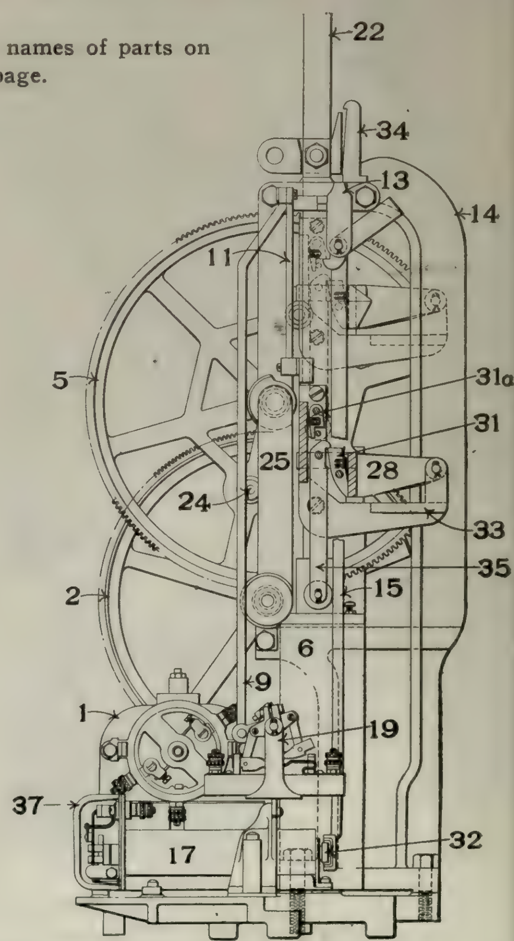


Fig. 522. Local Wiring for Two-Arm Style "F" Electric Motor Signal Mechanism.

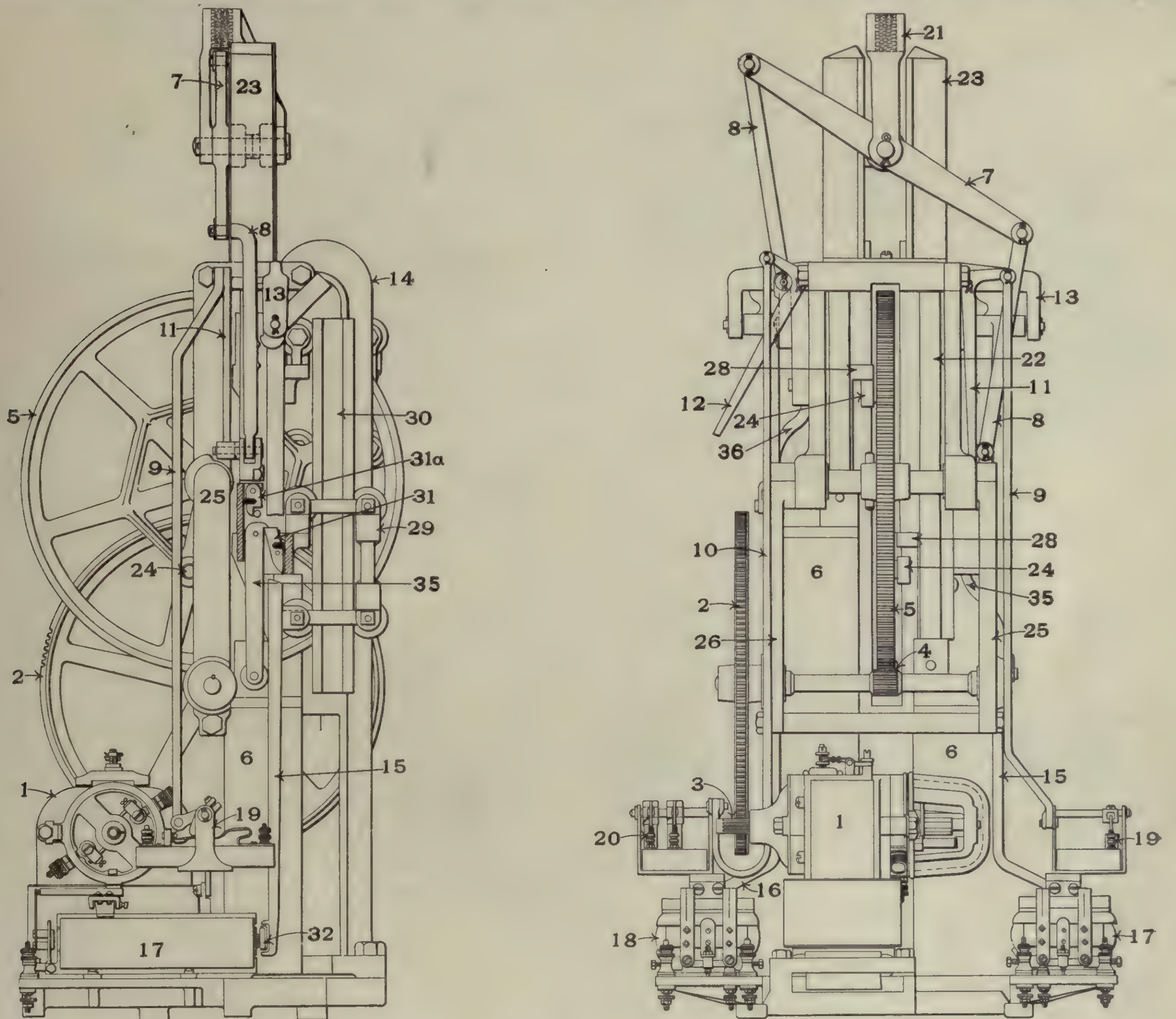
Numbers refer to lists of names of parts on following page.





Figs. 523-524. Style "F" Electric Motor Signal Mechanism. Hall Signal Company.

rod and all the parts attached to the clear position. In moving to the clear position the roller pivoted on the lower end of clearing lever 35 rolls along the front edge of clutch lever 15. In the last one-eighth inch movement of the signal to the clear position the roller attached to the latch support 33 strikes the front lever of the escapement crank 11 and moves stop by gravity. The movement of the signal to stop is cushioned by the dashpot 6. The circuit controllers are reversed as soon as the signal begins to go to the stop position. If by any chance the motor circuit should be closed without the clutch magnets being energized, the motor would simply revolve the gears, and when the stud roller engaged



Figs. 525-526. Style "F" Electric Motor Signal Mechanism, Equipped for Three-Position Signal. Hall Signal Company.

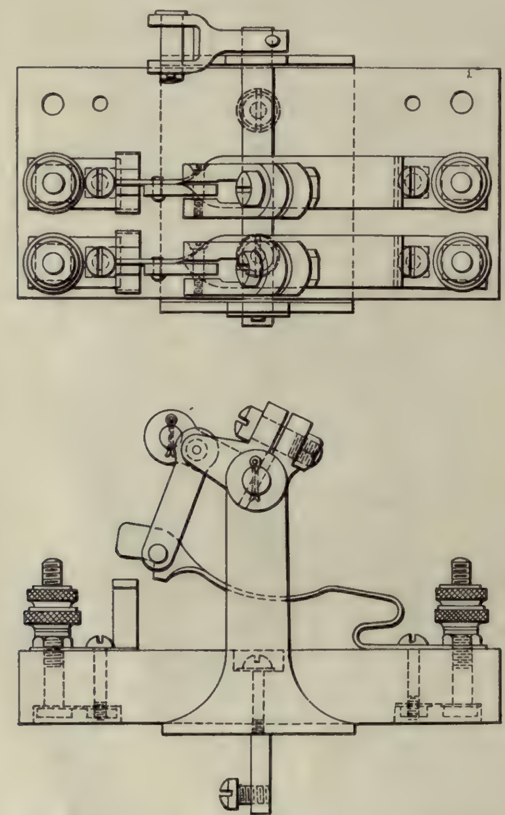
Names of Parts of Hall Electric Motor Signals; Figs. 523, 524, 525, 526. Two-Arm and Three-Position.

1 *Motor*
2 *Gear Wheel*
3 *Motor Pinion*
4 *Shaft Pinion*
5 *Driving Gear*
6 *Dash Pot*
7 *Rocking Beam*
8 *Rocking Beam Operating Rods*
9 *Circuit Closer Rod R. H.*
10 *Circuit Closer Rod L. H.*
11 *Escapement Crank R. H.*
12 *Escapement Crank L. H.*
13 *Clutch Lever Shaft Bearing*
14 *Frame*
15 *Clutch Lever R. H.*
16 *Clutch Lever L. H.*
17 *Clutch Magnets R. H.*
18 *Clutch Magnets L. H.*
19 *Circuit Closer R. H.*
20 *Circuit Closer L. H.*
21 *Screw Jaw*
22 *Thrust Rod*
23 *Thrust Rod Cover*
24 *Lifting Roller*
25 *Side Frame R. H.*
26 *Side Frame L. H.*
28 *Thrust Piece L. H.*
29 *Thrust Piece Carriage*
30 *Carriage Guide*
31 *Latch*
31a *Hold Clear Latch*
32 *Clutch Armature*
33 *Latch Support*
34 *Safety Latch*
35 *R. H. Clearing Lever*
36 *L. H. Clearing Lever*
37 *Glass Contact Cover*

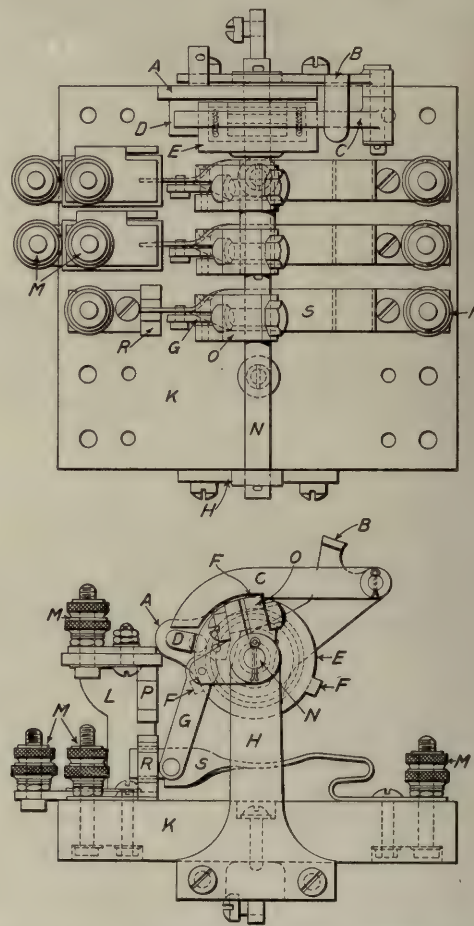
it on its pivot, and by means of the rod 24 operates the circuit controller. This opens the motor circuit and closes a contact in the distant signal circuit. The signal is held in the clear position by the lug on the clutch lever 15, engaging under a latch on latch support 33. This leaves the gears free to continue their movement, as soon as the distant clutch magnet is energized to clear the distant signal. After the signal has been cleared the stud roller 24 moves from under the thrust piece 28. When the signal circuit is broken the clutch magnet is de-energized. The front armature opens the motor contacts to keep the motor circuit open and the back armature being released permits the clutch lever 15 to swing back far enough for the holding latch in the latch support 33 to pass the lug on the clutch lever and allow the signal to go to the thrust piece it would raise it without affecting the signal. as the clearing lever 35 would be free to swing back and permit the latch 31 to pass it. When the stud roller passed from under the thrust piece it would drop back in place and be ready to clear the signal when the clutch magnet energized. Or if the clutch magnet should become de-energized when the signal was partly cleared, the clearing lever 35 would be permitted to swing back on account of clutch armature being released, and allow the latch 31 to pass the lug from the clearing lever, the signal would go to stop, the thrust piece 28 would remain on top of the stud roller by swinging on its pivot, and when the stud roller moved from under it, it would drop back in its place ready for another operation in which the parts would operate as described.

Names of Parts of Hall Pole Changer. Figs. 529-530.

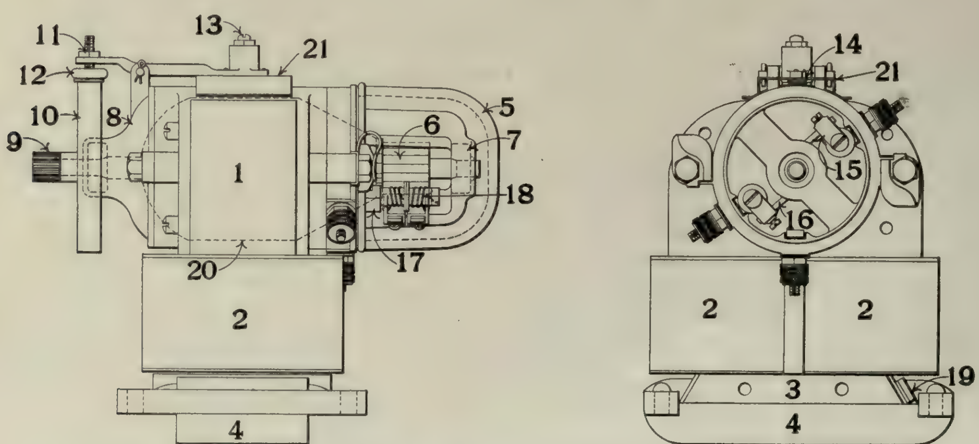
A *Disk Carrying Operating Pin*
B *End Bearing of Frame with Stop*
C *Pawl*
D *Lug on A*
E *Spring Case or Drum*
F *Lugs on E*
G *Insulating Link*
H *End Bearing of Frame*
K *Porcelain Base*
L *Bracket*
M *Binding Posts*
N *Shaft*
O *Clamp Arm*
P *Upper Contact*
R *Lower Contact*



Figs. 527-528. Circuit Controller for Automatic Signals. Hall Signal Company.



Figs. 529-530. Pole Changer for Automatic Signals.



Figs. 531-532. Electric Motor for Style "F" Mechanism.

Names of Parts of Electric Motor for Style "F" Mechanism; Figs. 531-532.

1 *Laminated Field Cores*
2 *Field Coils*
3 *Laminated Yoke*
4 *Base*
5 *Glass Commutator Shield*
6 *Commutator*
7 *Bearing Support, Front*
8 *Bearing Support, Back*
9 *Pinion*
10 *Brake Wheel*
11 *Brake Adjusting Screw*
12 *Brake Shoe*
13 *Brake Armature Screw*
14 *Brake Armature Spring*
15 *Brush Holder*
16 *Brush*
17 *Brush Holder Support*
18 *Brush Holder Tension Spring*
19 *Wedge*
20 *Armature*
21 *Brake Armature*

Figs. 521-522 show circuits for wiring the mechanism of a one and two-arm Style "F" Hall motor signal. The full lines represent wiring furnished with the mechanism, the dotted lines the wiring which must be done after the signal has been installed. Fig. 522 is used when this signal is in the normal danger system (see Figs. 502-504); Fig. 521 may also be used when this style of signal is used as a power operated signal at an interlocking plant.

Figs. 525-526 show front and side elevation of a three-position Style "F" motor mechanism. This is identical in construction with the mechanism shown in Figs. 523-524, except for the addition of several parts. (Numbering of parts is the same as in Figs. 523-524.) Two guides, 23, for the thrust piece, 22, are mounted on top of the frame. These act also as guides for the jaw, 21, which is attached to the up-and-down rod. 21 carries the rocking beam, 7, each end of which is attached to one of the thrust rods, 22, by means of link 8. Thus, raising one-half of the mechanism as shown puts the signal to the 45-deg. or caution position. Raising both parts clears the signal. No glass covers are shown on 17 and 18.

A view of the Hall Signal Co.'s circuit controller (19 and 20, Figs. 523-524, 525-526, 15, Fig. 585) is shown in Figs. 527-528. It consists of a porcelain base to which a bronze frame is secured. The base also supports the spring knife switches, the contacts and the binding posts. The frame acts as a bearing for a shaft and also as a means of attachment to the mechanism. The shaft carries one or more clamped arms to which are secured links made of fiber. To the lower end of these links the spring knife contacts are fastened.

The pole changer made by the Hall Signal Co. is shown in Figs. 529-530. K is a porcelain block. H is the brass frame carrying the shafts, N, and serving as a means of attachment to the signal mechanism. L is a bronze support for the upper contacts, P, and binding posts. All binding posts, M, are similar. Clamp arms, O, are fastened to the shaft and carry insulating links G. These links actuate the knife blades, S. Lower contacts, R, are similar to upper contacts, P. Attached to the shaft, N, is a drum, E, within which there is a spiral spring, one end fastened to the drum, the other to disk A. A moves loosely on N and carries a pin to which the operating rod is fastened. Suppose A to be revolved to the right. Motion would be imparted to E through the spring, but one of the lugs, F, would catch in the notch of pawl C, which is pivoted to the frame. This would prevent E and N from revolving so that further motion of A would compress the spring. When A reaches a point where lug D strikes pawl C and raises it, the spring will cause E and N to snap over and carry the knives S to the upper contacts P. C is prevented from flying too far by stop B. When A is revolved to the left, lug D strikes a second lug F on E, and thereby moves knives S to the lower contacts by means of N and G.

UNION STYLE "B."

The two-arm motor signal mechanism made by the Union Switch & Signal Company is shown in Fig. 535. Fig. 537 shows the same mechanism partly in section. The operation of the slot-arm is shown in Figs. 540-542. When the signal position shown at A, Fig. 537, the lugs S, on the fork head 5 engage hooks on the pawl 24 (shown dotted in Fig. 537). This supports the arm in the clear position. In assuming this position the top of slot-arm strikes against the lever 46. This causes the insulated block 39 to raise contact spring 28 off of contact spring 29, thereby opening the motor circuit and stopping the motor. It also closes the circuit for the distant

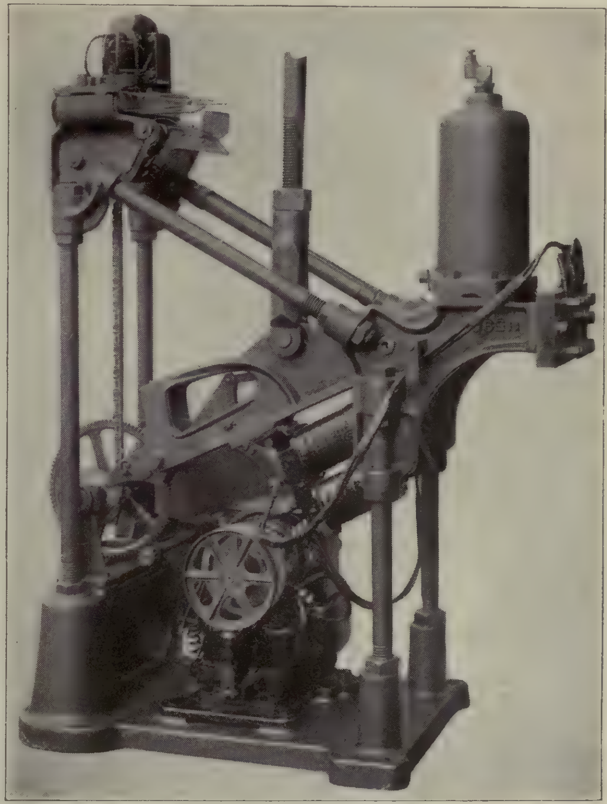


Fig. 533. Union Style "B" Electric Semaphore. One-Arm Two-Position Left-Hand Upper Quadrant Signal (60-deg.) Furnished for the Illinois Traction System and Equipped for A. C. Operation.

signal (Fig. 534). In order that pawl 24 shall be certain to engage lugs S, a spring, 45, is fastened to lever 46. Its lower end bears on pawl 24, therefore, the raising of lever 46 by the slot-arm puts tension on the spring and forces pawl 24 into engagement with the lugs S. When the slot magnet is de-energized the armature 4 falls away by gravity. This releases latch D, permitting link F and fork head 5 to assume the positions shown in Fig. 542. This allows the signal to go to the stop position. A dashpot 8 provides an air cushion to absorb shocks. Fork head spring 35 restores the fork head to its normal position after the slot-arm has passed the trunnion or pawl when returning to the stop position. One feature of this signal is the arrangement of parts whereby the slot armature 4 moves both to and away from the pole pieces by gravity. The distant slot 7' clears the distant signal in ex-

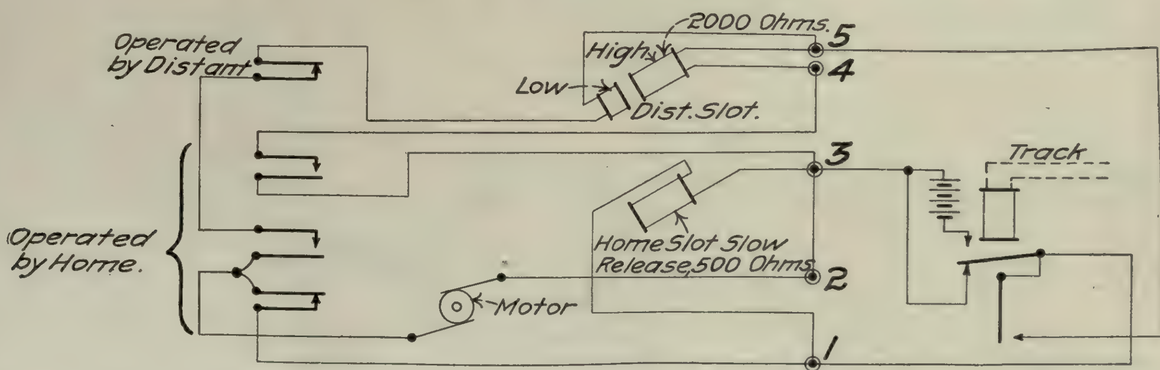


Fig. 534. Wiring Diagram for Style "B" Automatic Signal When Operated by Direct Current and Controlled by Polarized Relay.

is in the stop position and current is supplied to clear it, the operation is as follows: (For circuit see Fig. 534.) Current passes from relay to home slot coil 7 and motor M (see Fig. 537) in multiple. The motor revolves the gear 3 by means of the large gear 1 and pinion 2. This causes the trunnion 12 on chain 10 to engage the prongs of the fork head 5, and move the slot-arm about G (see Fig. 540) as a center. This clears the signal which is operated by an up and down rod attached at K by jaw 6. When the slot-arm has reached the

actly the same way as the home was cleared, except that it has two windings, one high and one low (see Fig. 534). Connecting link 31 is used to actuate a pole-changer P or circuit controller C for the control of outside circuits. Single arm

Fig. 534 shows the arrangement of local wiring when used with the polarized track circuit, as shown in Fig. 496.

The slow release on the home slot magnet is accomplished by means of a copper sleeve over the core of the magnet inside

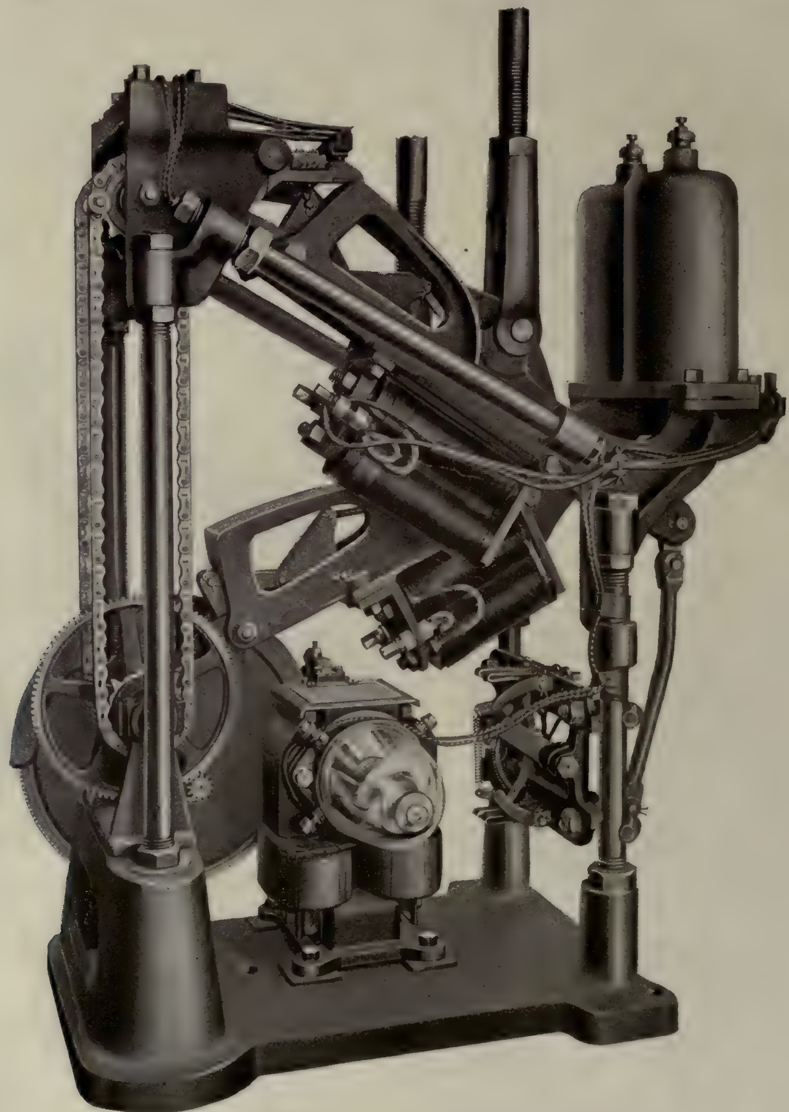


Fig. 535. Style "B" Electric Motor Signal Mechanism; Home Slot in Clear Position; Distant Slot at Caution. Union Switch & Signal Company.

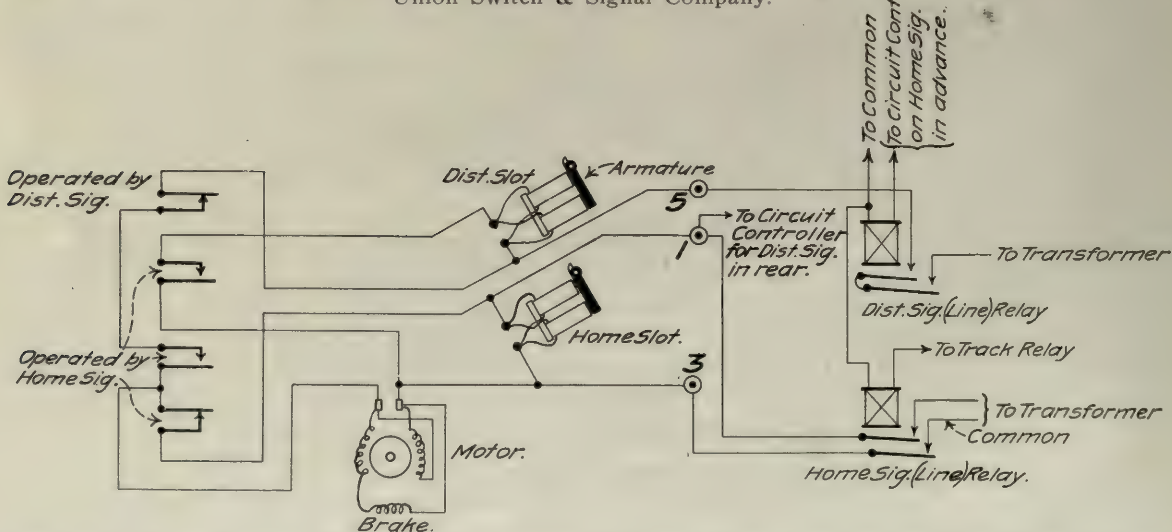


Fig. 536. Wiring Diagram for Style "B" Automatic Signal When Operated by Alternating Current.

mechanisms are furnished with only one slot-arm, sprocket, chain, and dashpot. Fig. 539 is a view of the gear and sprocket wheels with their bearings and chains. This constitutes the running gear of the mechanism.

the coil. This acts as a short-circuited winding of large current capacity which induces sufficient magnetism in the core to keep it energized a short time after the current has been cut off from the coils on account of the current induced

in it when the holding circuit is broken. The object of this arrangement is to hold the home arm clear while the track relay is momentarily de-energized by the reversal of the track circuit. This slow acting feature is required only in the polarized system.

The back contact on the neutral armature of the relay also assists in the slow release of the home slot, by closing a local circuit, without battery, through it when the relay is de-energized, thereby allowing self-induced current to flow through the slot coil.

The compound winding on the distant slot magnet is provided to economize in the use of current. The motor circuit

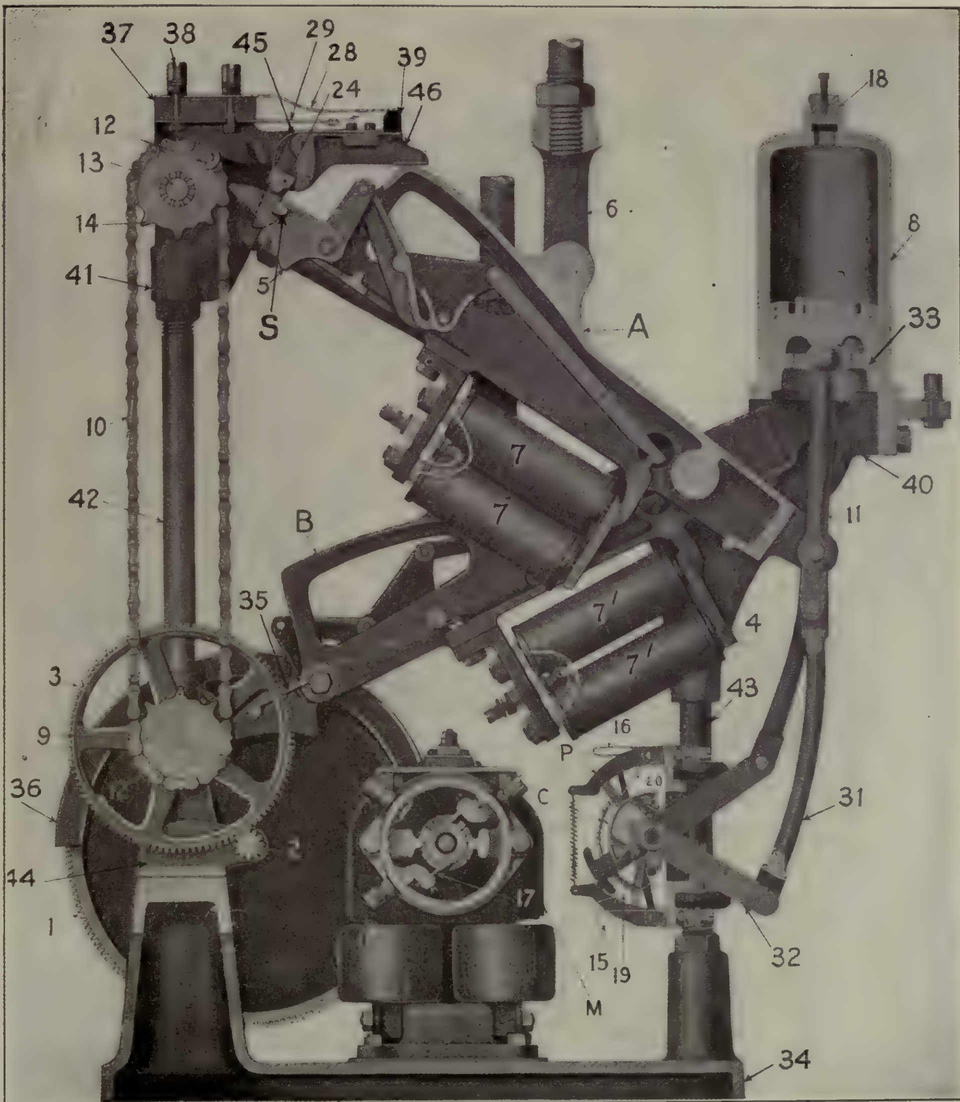


Fig. 537. Sectional View, Style "B" Motor Mechanism. Union Switch & Signal Company.

Names of Parts, Union Style "B," Motor Signal Mechanism; Fig. 537.

1 *Main Gear Wheel*
2 *Counter Shaft and Pinion*
3 *Intermediate Gear Wheel*
4 *Slot Armature*
5 *Forked Head*
6 *Screw Jaw*
7 *Pair Home Slot Magnets*
7[1] *Pair Distant Slot Magnets*
8 *Buffer Cylinder*
9 *Lower Sprocket Wheel*
10 *Chain*
11 *Piston Rod for Buffer Cylinder*
12 *Trunnion*
13 *Upper Sprocket Shaft*
14 *Upper Sprocket Wheel*
15 *Lower Contact Spring for Pole Changer*
16 *Upper Contact Spring for Pole Changer*
17 *Motor Brush*
18 *Check Valve for Buffer Cylinder*
19 *Lower Contact Spring for Circuit Controller*
20 *Upper Contact Spring for Circuit Controller*
24 *Pawl for Supporting Slot-Arm*
28 *Long Contact Spring*
29 *Short Contact Spring*
31 *Pole Changer Operating Link*
32 *Operating Arm for Pole Changer*
33 *Piston for Buffer Cylinder*
34 *Mechanism Base*
35 *Coil Spring for Forked Head of Slot-Arm*
36 *Main Gear Shield*
37 *Slate Base for Contact Springs*
38 *Binding Post*
39 *Insulation for No. 46*
40 *Buffer Cylinder Bracket*
41 *Contact Spring Board Bracket*
42 *Long Upright for Frame*
43 *Short Upright for Frame*
44 *Bearing Bracket*
45 *Spring for Circuit Closing Lever*
46 *Circuit Closing Lever*
A *Home Slot-Arm Casting*
B *Distant Slot-Arm Casting*
C *Contact Piece for Circuit Controller*
D *Latch*
E *Three Way Crank*
F *Link with Stop*
M *Motor*
P *Pole Changer*
S *Lug on 5*

passes through the low resistance winding and is opened when the distant arm reaches the clear position The slot then holds the arm clear by current in the 2,000-ohm coil only.

Fig. 536 is a wiring diagram used in place of that shown in Fig. 534 when the signal is to be operated by alternating current.

Fig. 538 shows the double arm mechanism (Figs. 535-537) equipped to operate a single arm three position signal. The up and down rod terminates in a jaw carrying a pinion. This pinion engages on each side with a rack operated by each slot-arm. The pinion and two racks are enclosed in a case clamped to the frame tubing. Thus, when one slot-arm is raised its rack revolves the pinion which travels upward on the other rack. This puts the signal in the intermediate position. Raising of the second slot-arm causes the pinion to travel up the first rack and completes the stroke of the signal.

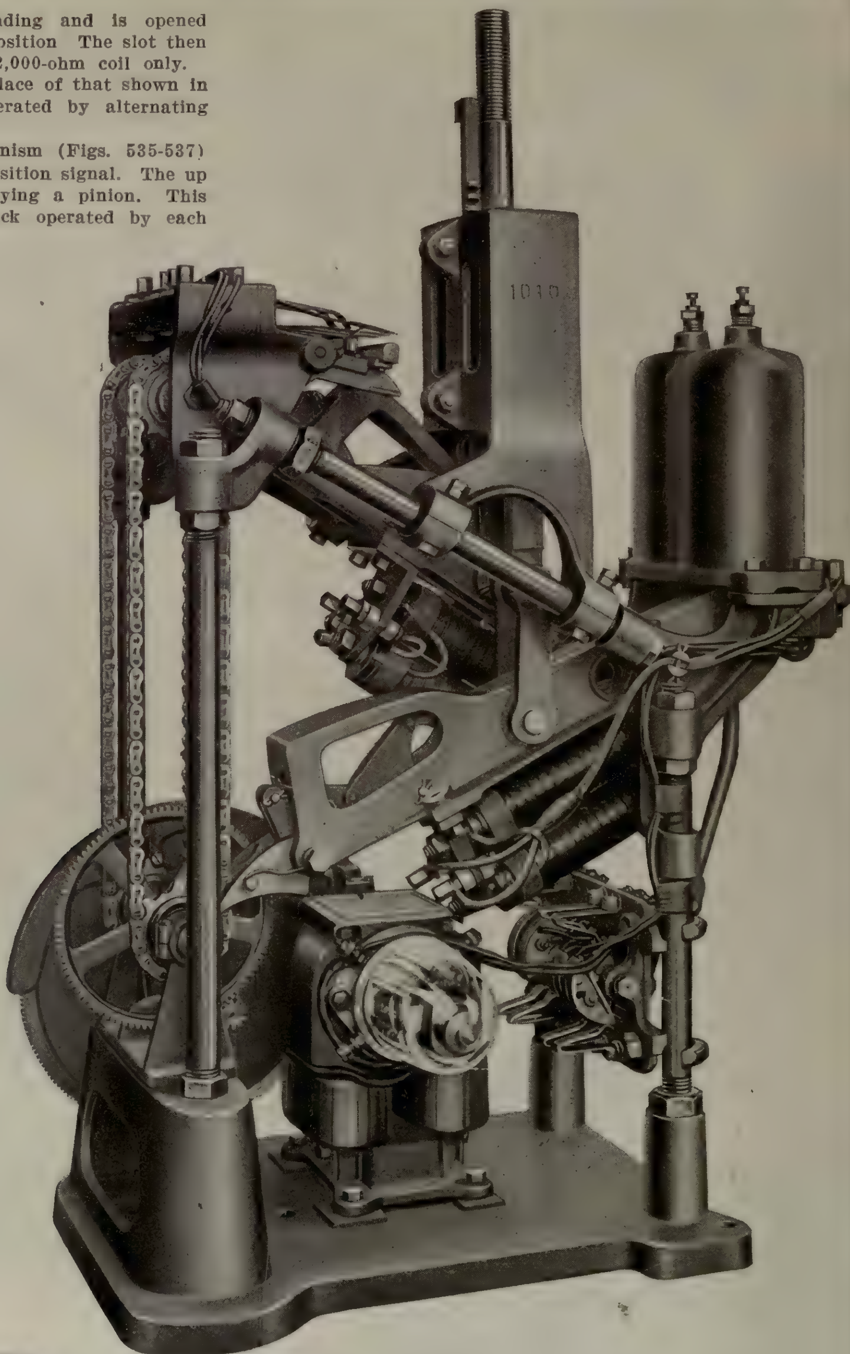


Fig. 538. Style "B" Mechanism Equipped for Three-Position Signal. The Union Switch & Signal Company.

The direct current motor (Fig. 544) is series-wound and is usually designed to work on 12 volts. Its brake is controlled by the field magnet, and its commutator is protected by a glass shield, as shown.

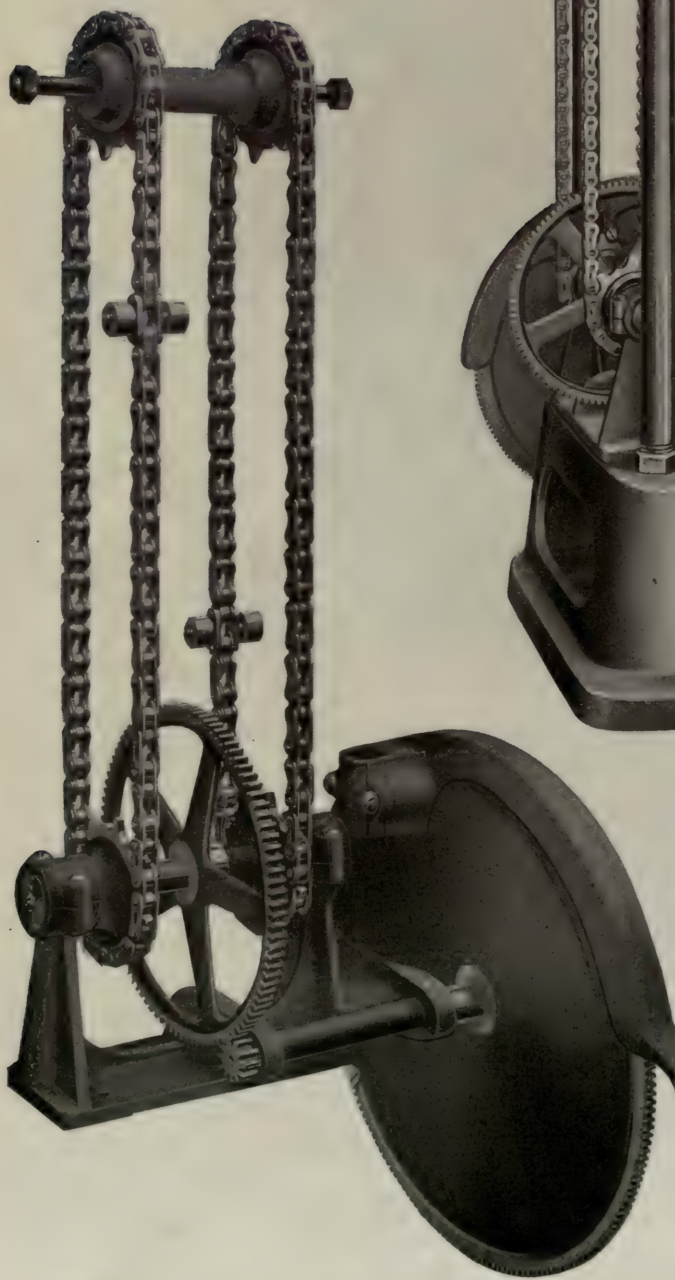


Fig. 539. Running Gear and Shield, Style "B" Motor Signal. The Union Switch & Signal Company.

UNION STYLE "S."

The Style "S" signal is a development of the above-described Style "B" signal along lines adapted to meet the requirements of three-position automatic block signaling.

The signal has been designed to work with either direct or alternating current, shaded pole slot magnets and induction motor being used in the latter case.

In the Style "S" three-position signal but one slot arm with its transmission parts is employed for the operation of each semaphore arm. An air buffer is pivoted to the frame imme-

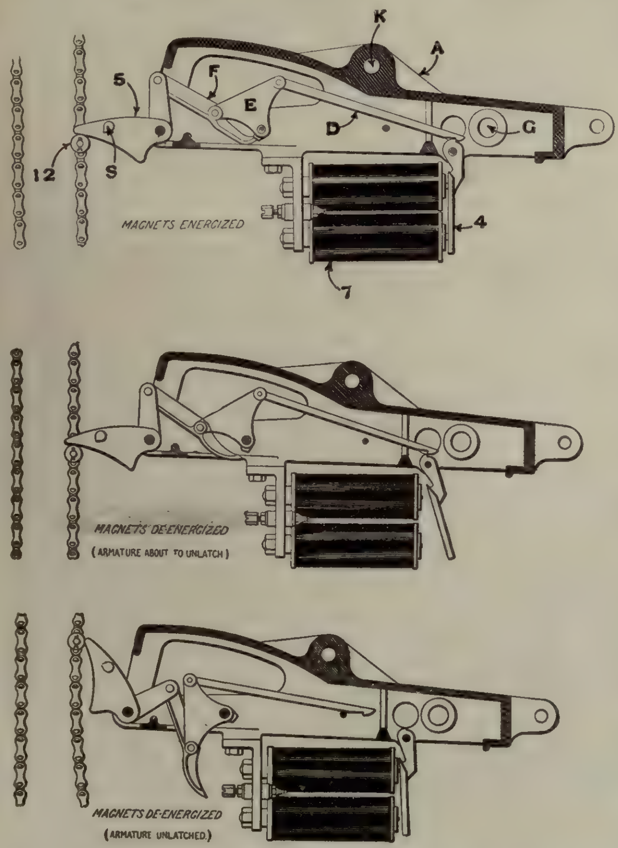
diately below the point on the slot arm to which the vertical signal rod is attached.

The upper end of the buffer piston rod and the lower end of the signal rod are fitted with jaws and connect to the slot arm with one common pin in the same manner as the well-known wide and narrow jaws are connected to a crank in mechanical interlocking practice. This method transmits the shock of the signal arm when returning to "stop" directly to the buffer.

The main circuit controller, to which a pole changer can be applied when required, is located to the right and above the slot arm, thus providing space for two relays in each mechanism case and keeping the controller contacts out of the way of oil and dirt.

The base of the controller is made of porcelain dipped in black insulating varnish. By this means all hidden insulations liable to be charred by lightning, such as bushings and washers, are dispensed with. The controller is equipped throughout with non-turning binding posts and otherwise is designed to comply with Railway Signal Association requirements.

The circuits for the intermediate or 45-deg. position of the arm pass through this controller, which also serves as a main



Figs. 540-542. Sections Through Slot Arm, Showing Successive Positions, Style "B" Mechanism.

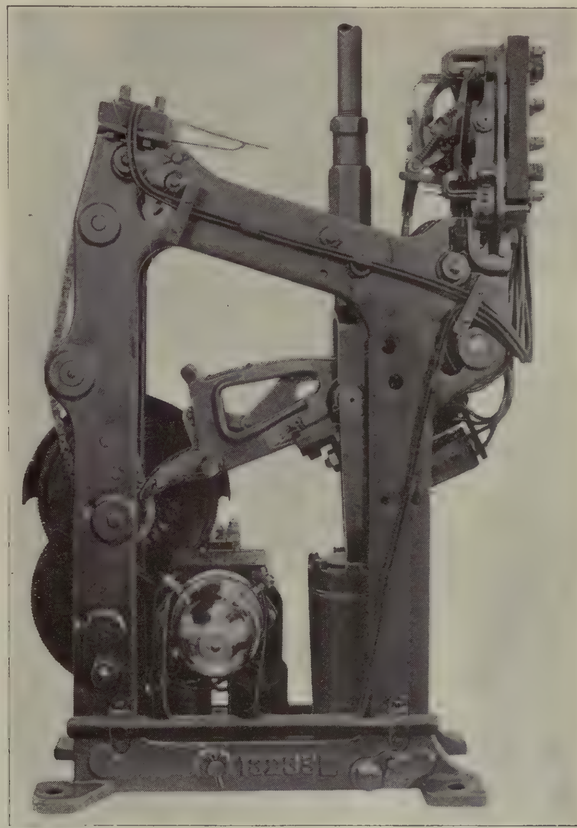


Fig. 543. Union Style "S" D. C. Motor Mechanism.

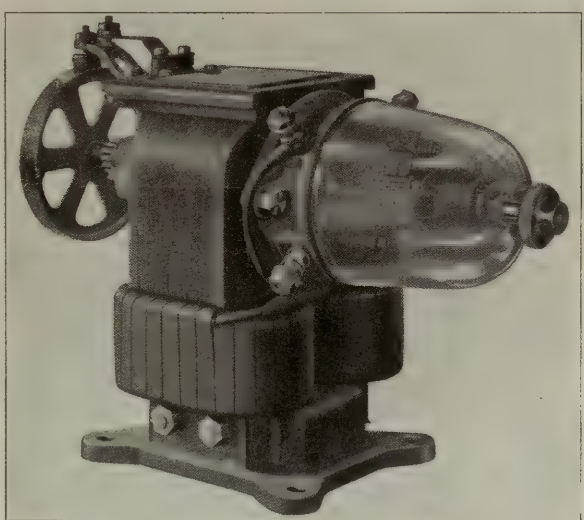


Fig. 544. Electric Motor for Style "B" Automatic Signal.

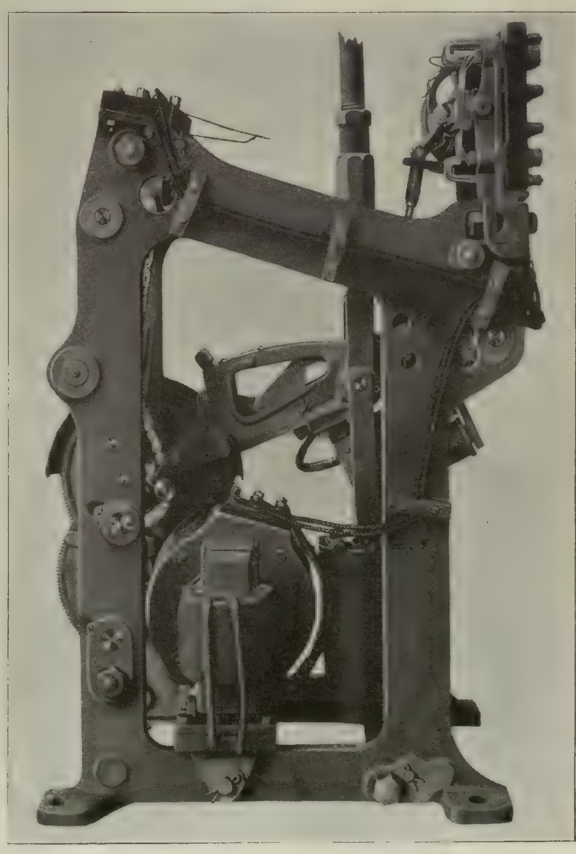


Fig. 545. Union Style "S" A. C. Motor Mechanism.

terminal board for the mechanism. Additional circuit controllers are carried on the left-hand upper corner of the mechanism and operated directly by the slot arm.

The slot arm is identical in design and principle with that

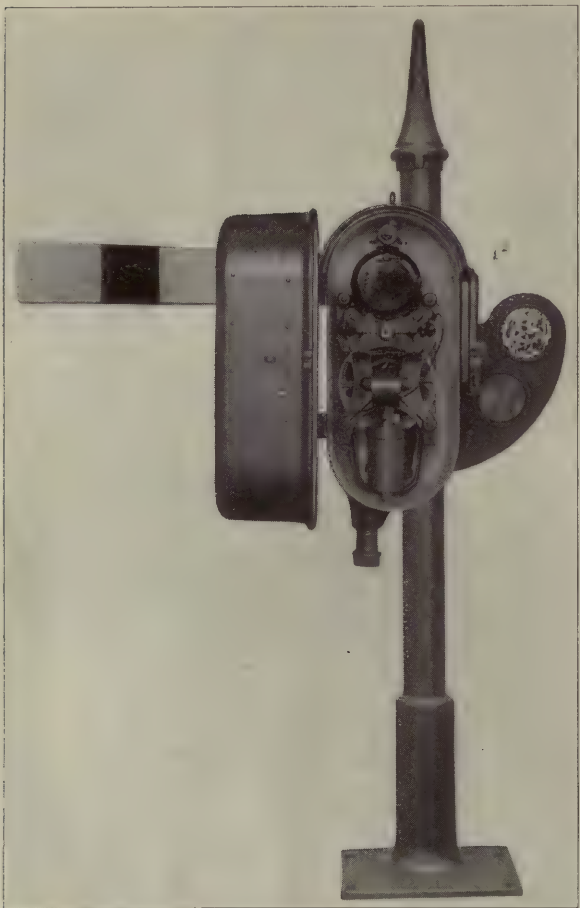


Fig. 546. Union Style "E" Motor Mechanism.

used on the style "B" except that the fork head or lifting crank is three-pronged.

Two chains are employed, the center lines of which are tangential to the arc described by the slot arm. The lower chain lifts the slot arm from the "stop" to the "caution" position, and the upper from the "caution" to the "clear" position. The chains are staggered with relation to each other, the lower engaging the front and middle prongs of the fork head, and the upper the middle and rear prongs.

The slot arm rests on hooks in both the caution and clear positions, thus retaining two of the important features of the Style "B" signal, viz.: (1) The clear and caution positions are definite and do not depend on the adjustment of circuit controllers; and (2) in both these positions the signal is entirely free from its running gear. The mechanism frames are of cast iron, secured to each other by steel bolts and spacers.

The motor straddles a pin passing through both frames, to which it is secured by set screws. A connection between the motor and a cam on the frame permits of adjustment between the motor pinion and the gears.

By a modification of the slot arm leverages on both the Style "S" and "B" mechanisms the mechanical kick-off or the counterweight effect tending to force the slot armature away from the magnet coils has been increased 175 per cent without increasing the current consumed for holding the signal at clear or caution.

UNION STYLE "E."

The signal mechanism illustrated in Fig. 546 is the Style "E" top post, adapted to either lower or upper quadrant indication, for operation by direct current at any desired voltage, or by alternating current of any frequency and voltage.

In this mechanism the motor is never operated in reverse direction, a clutch being interposed between the semaphore shaft and the gearing by which the motor operates the signal in one direction. This clutch is under the control of an electromagnet, which, when energized, holds the gearing between the motor and semaphore shaft continuous; and when the magnet is de-energized the continuity is interrupted and the signal returns by gravity, independently of the motor and the gearing.

Another unique feature in connection with this signal is in the design of buffer, which is composed of a cylinder and a piston moving therein, which latter has a complete reciprocating movement for each 45 deg. movement of the signal;—in other words, a suction and a compression stroke. Because of comparatively high speed of the piston within the cylinder that is obtained by this arrangement, a very loose fit of the piston within the cylinder, without the use of rings, is permissible, while a highly effective buffing effect is obtained.

UNION STYLE "T."

In this mechanism the motor is geared to the semaphore shaft so that its armature rotates with the semaphore shaft in either direction. The ratio of gearing of the motor to the shaft is so low that the effort of turning the armature offers very little resistance to the descent of the counterweight. Electromotive force is applied to the motor when the signal is going

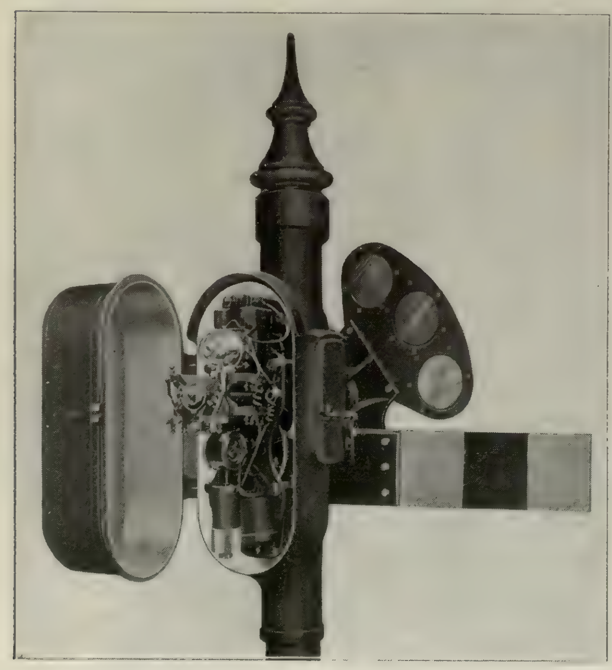


Fig. 547. Union Style "E" Motor Mechanism.

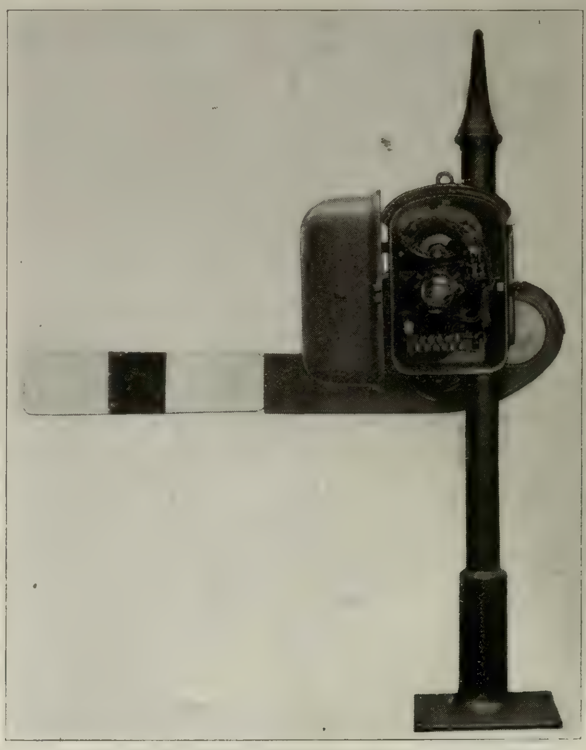


Fig. 548. Union Style "T" Motor Mechanism.

toward the danger position, so as to assist the counterweight. Normally no current is used in going to danger, because the counter electro-motive force of the motor driven by the counterweight exceeds the electro-motive force of the battery, but if anything should occur to offer unusual resistance to motion the motor would assist in putting the signal to danger.

The motor acts as a brake after the current is cut off when running in either direction. This is useful when the signal is going to the caution or clear position, as it prevents overrunning no matter how the voltage may vary and when the signal is going to danger, as it brings the arm to rest gently on the stop.

The signal is adaptable to either high or low voltage, direct current.

G. R. S. MODEL "2A."

Figs. 549-563 shows views of direct connected and base of mast Model 2A mechanism for automatic block signaling. They are designed to be operated by alternating current of any voltage and frequency or by low voltage direct current. The mechanisms will control any aspect, two or three positions of the semaphore blade, upper or lower quadrant, right or left hand and through any angle of movement desired up to 90 deg.

The direct connected signal is clamped to the mast by means of a clamp bearing which enables it to be mounted anywhere on new or existing poles, or any number on a given pole. To assure proper alignment, the driving and semaphore shafts are connected by a coupling which lends itself to a simple means of locking the semaphore in the normal position, this preventing improper operation of the signal by any outside agency. The motor is directly connected to the semaphore shaft through a train of gears so that the armature revolves with it in either direction. By the use of a high torque, low speed motor, low reduction gearing is used, but 30 revolutions of the motor being required to clear the signal to the 90 deg. position.

The direct current signal is held in the desired proceed positions by means of a retaining device (Fig. 555) with which the motor is equipped. It consists of an electro-magnet, the armature of which is connected, through a crank and link movement, to a dog designed to engage a toothed disk mounted on the armature shaft of the motor; the design embodies an escapement movement so that when the electro-magnet is energized, the motor armature will be held only when it begins its rotation toward the stop position. An exceedingly high drop away is procured through having an air gap of .020 of an inch, this being more than twice the air gap ordinarily used in connection with this type of mechanism.

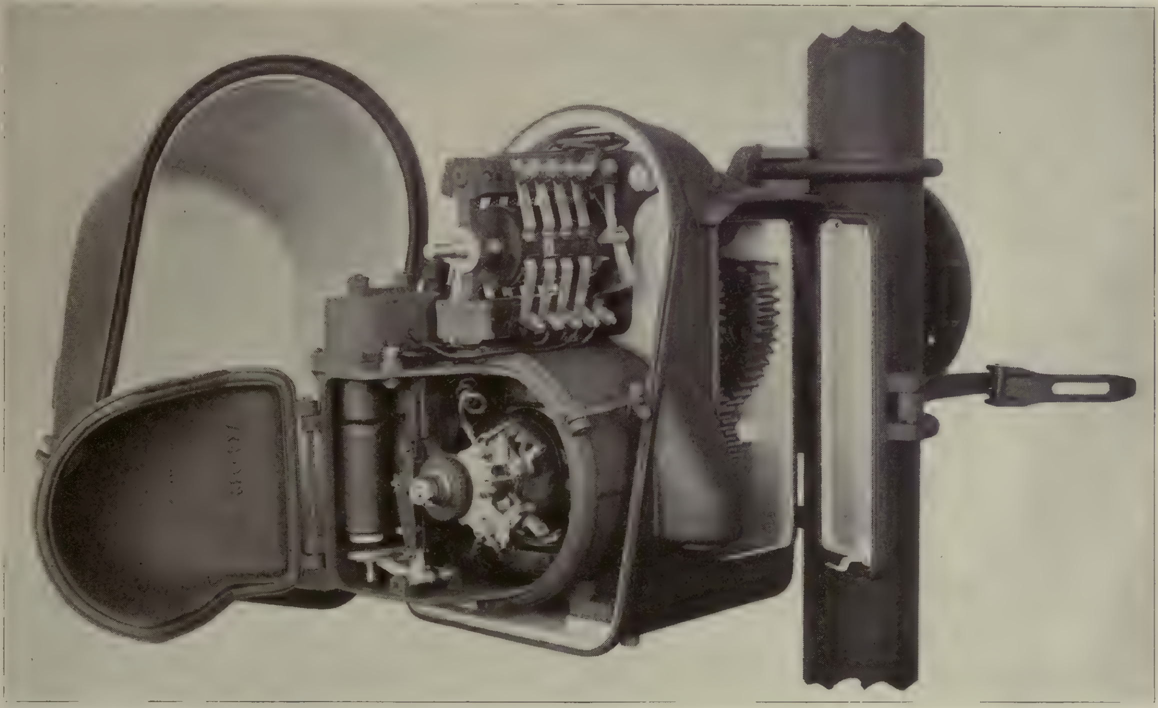


Fig. 549. Model "2-A" Direct Connected Signal Mechanism. Low Voltage, D. C. Control. General Railway Signal Company.

Due to the motor being driven backwards when the semaphore is returning to the stop position, electrical means may be used for stopping the movement of the signal blade, without the use of a dash-pot or other additional mechanical contrivance. This is accomplished in the last few degrees' movement of the mechanism by shunting the motor, which causes it to generate sufficient current to effectively check the

Fig. 550. Model "2-A" A. C. Suspended Signals. New York, New Haven & Hartford Railroad.

Fig. 551. Model "2-A" D. C. Automatic Signals. Northern Pacific Railroad.

speed of the mechanism so that the signal parts and semaphore blade are brought to stop without shock.

The motor used for a. c. operation may be either of the stator winding and its laminated iron core, the latter being mounted on the armature shaft of the motor. When the mechanism is assuming the proceed position, the core, through

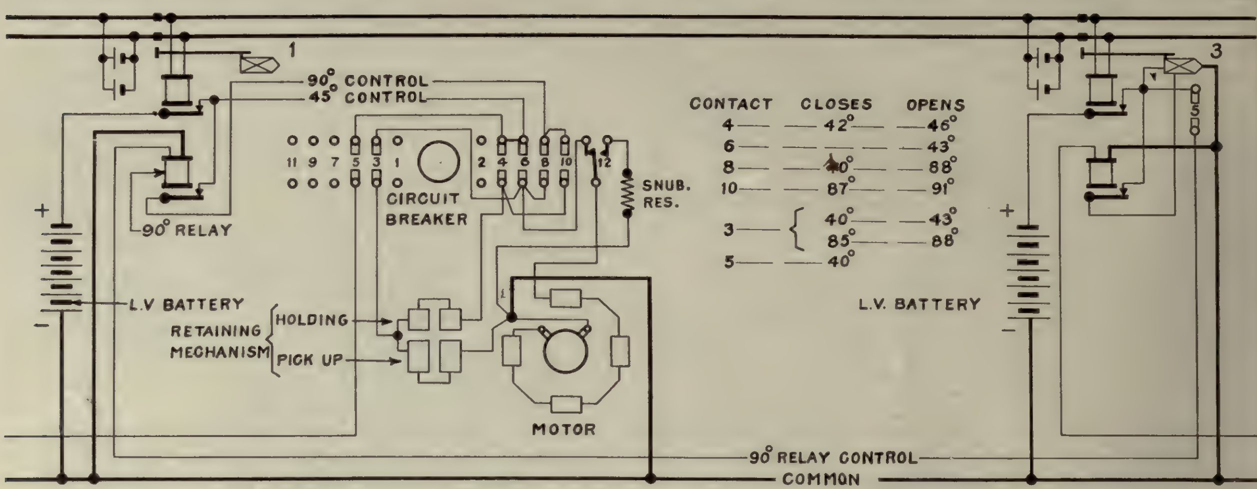


Fig. 552. Wiring Diagram for Model "2-A" Automatic Signal. Low Voltage D. C. Control.

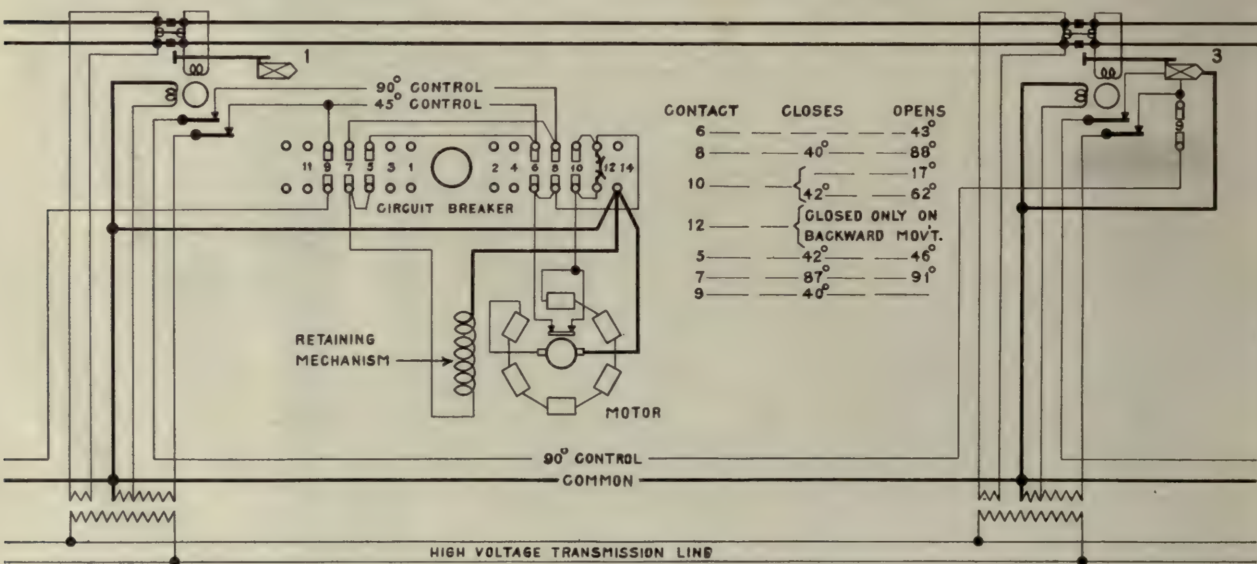


Fig. 553. Wiring Diagram for Model "2-A" Automatic Signal, A. C. Control.

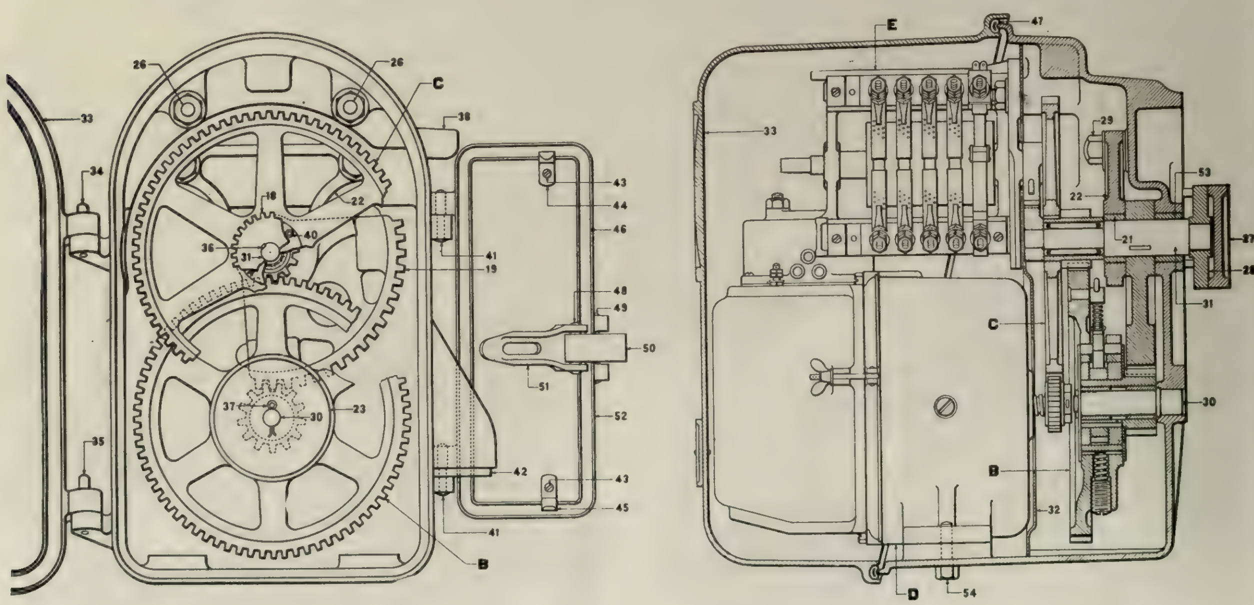


Fig. 554. Universal Model "2-A" Direct Connected Signal Mechanism. General Railway Signal Company.

commutating or induction type, both of these motors having such efficiency that they may operate directly over the line without the intervention of line relays. The a. c. signals are held in the different proceed positions by means of a the medium of a simple and efficient clutch, remains stationary when its stator winding is energized; the moment reverse movement starts to take place, the clutch clamps this core to the armature shaft and holds the signal blade in the

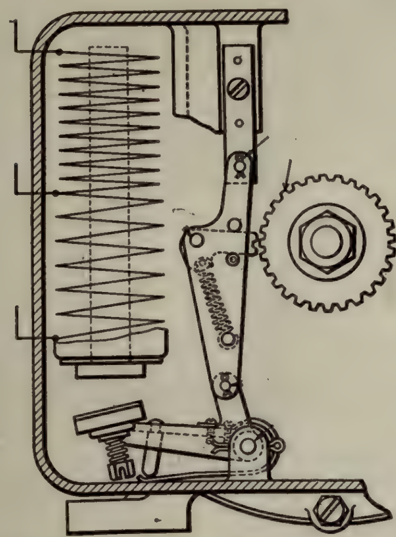


Fig. 555. Retaining Mechanism. Model "2-A' Low Voltage D. C. Signal.

position to which it has been moved. The operation of holding the blade clear is not dependent on mechanical contact in any way, but is due entirely to torque produced by lines of flux flowing between pole surfaces separated by a large air gap; when the retaining current is cut off, the torque existing between the core and stator pole pieces ceases to exist and the blade returns to the stop or next lower position, as the case may be. Figs. 556-557 are views of complete and partial assemblies of the retaining device.

In the base of mast signal the same motor, gearing and circuit breaker parts are used as in the direct connected type. The frame is designed to carry one or two mechanisms, which will operate one or two arms respectively, controlling any aspect, two or three positions, etc. Space is available at the top of the case for control and track relays, and at the side for lightning arresters and fuse and terminal boards.

The wiring for the a. c. and d. c. mechanisms and circuits for their control are shown in Figs. 552-553.

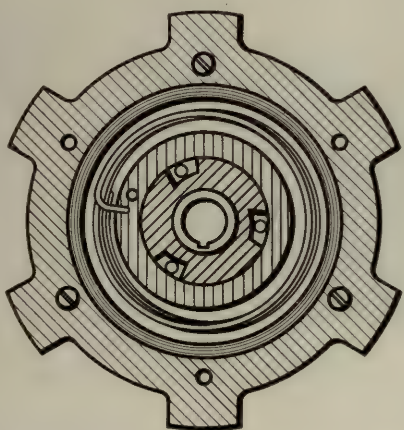


Fig. 556. Rotor of Hold Clear Reactance Model "2-A" A. C. Signal.

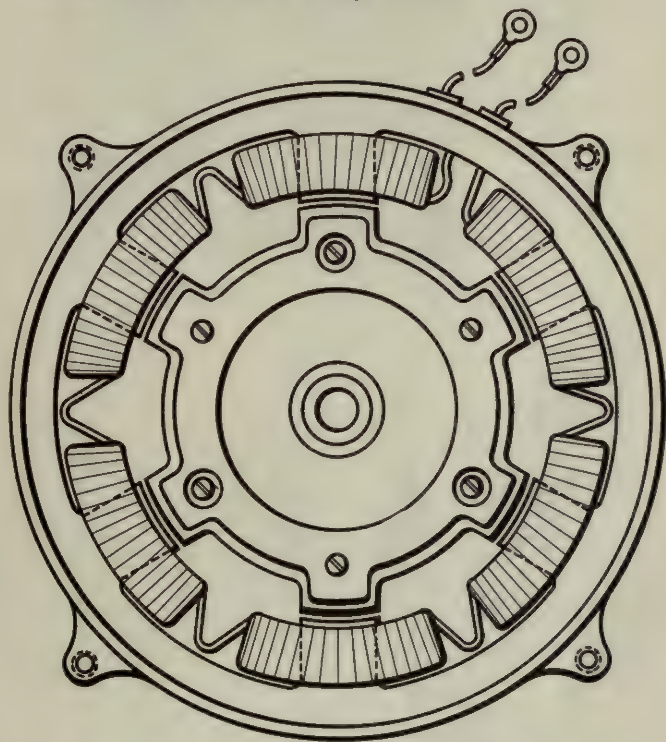
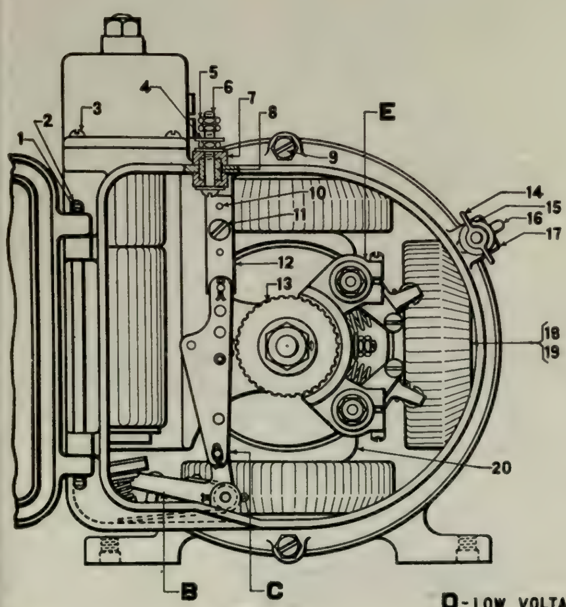
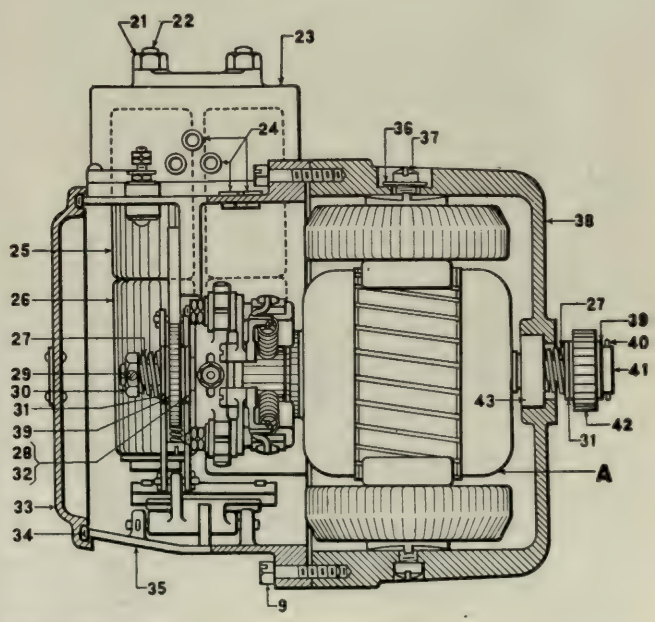


Fig. 557. Hold Clear Reactance. Model "2-A" A. C. Signal.





Figs. 558-559. Motor for Universal Model "2-A" Signal. Low Voltage D. C. Control. General Railway Signal Company.

Fig. 560. Universal Model "2-A" Base-of-Mast Signal Mechanism. A. C. Control.

Fig. 561. Model "2-A" A. C. Bracket Signals. Long Island Railroad.

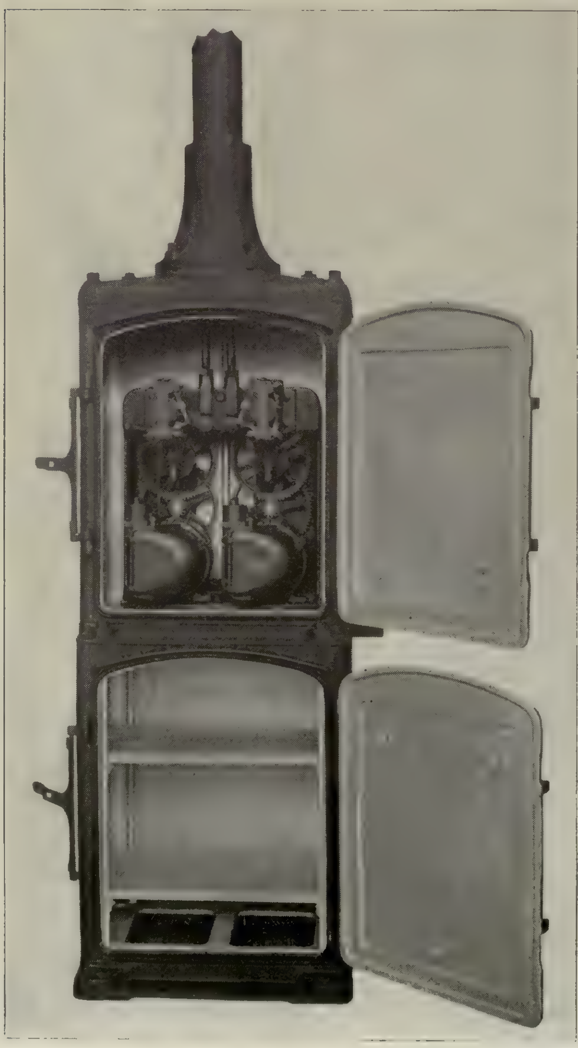


Fig. 562. Model "2-A" Base-of-Mast Signal Mechanism. Low Voltage D. C. Control.

Fig. 563. Model "2-A" D. C. Automatic Block Signal. Northern Pacific Railroad.

Hall Style "H."

Figs. 564-566 illustrate the Style "H" top post electric semaphore signal made by The Hall Signal Co.

The operating mechanism, a general view of which is shown in Fig. 566, is composed of the motor and its gears, a clutch magnet of the disc type with its armature, and the circuit controller. The holding mechanism, shown in Fig. 565, is composed of a piston and cylinder with oil reservoir and valves, and the holding magnets.

The clutch magnet "a" (Fig. 570) is keyed to the semaphore shaft by key "b" and the armature "c" is held in position by pins "d" in the clutch magnet, so that the armature revolves with the magnet, but is free to move laterally. A Norway iron clutch ring "e" is fitted into the large gear "f" and is placed between the clutch magnet and its armature. This clutch ring revolves with the gear, independent of the clutch magnet and armature, and, like the clutch armature, is allowed a slight lateral motion. When the power is applied to the motor, the large gear "f," which is connected to the motor pinion by a chain of gears, revolves and carries with it the clutch ring. The circuit through the clutch magnet is in multiple with the motor circuit, and is closed when the motor circuit is completed. Since the clutch ring is between the clutch magnet and its armature, it is clasped rigidly between them by the force of attraction, and the clutch magnet and semaphore shaft, to which it is attached, are forced to revolve with the clutch ring and large gear, thus clearing the semaphore blade. When the blade reaches the 45-deg. position, the circuit for the motor and clutch is opened through the circuit controller operated by the clutch magnet, and the blade is free to come to rest or return to the stop position. If the contact on the distant relay is closed, however, the circuit for the motor and clutch is again completed by a

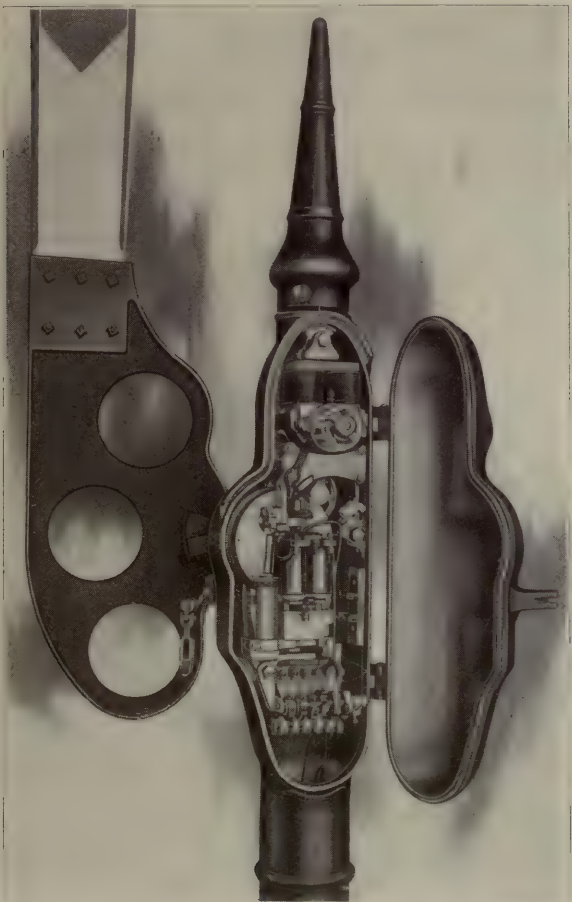


Fig. 564. Style "H" Signal in Case. Hall Signal Company.

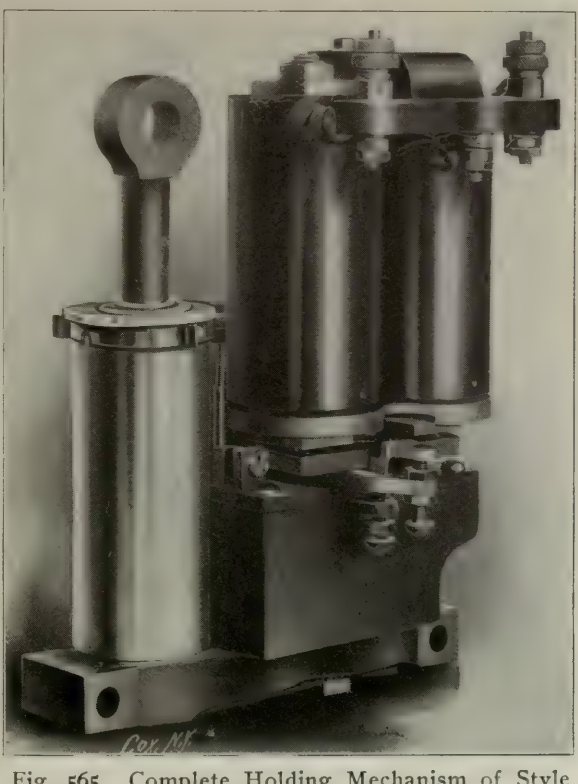


Fig. 565. Complete Holding Mechanism of Style "H" Signal.

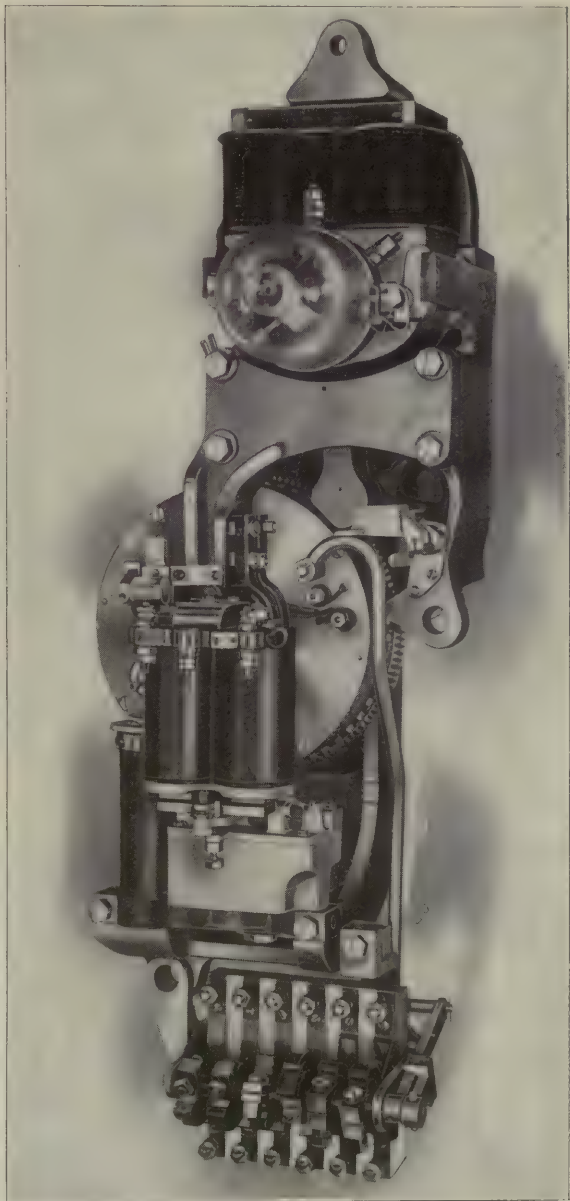


Fig. 566. Style "H" Mechanism. Hall Signal Company.

multiple circuit, and the blade is moved to the clear position, when this circuit is again opened by another contact on the circuit controller. Fig. 567 shows the circuit which controls the operating functions of the mechanism. All the movements of the blade from the danger position are accomplished in the manner described, and no apparatus other than the motor, gears, circuit controller and clutch magnet are required for this function.

The blade is held in its position of rest by the holding mechanism in the following manner: The piston "g" (see Fig. 569) connected to the clutch magnet by rod "h" moves in cylinder "j." The cylinder is connected to the oil reservoir "k" by the port "l," this port being controlled by valves "m" and "n." Valve "m" is connected to the armature of the holding magnets by stem "r," and when these magnets are energized, the valve "m" is closed. Valve "n" is automatic in action; with valve "m" closed, and with a weight on the piston tending to force the liquid from the cylinder to the reservoir, valve "n" is closed by the pressure of liquid against it, and both passages from the cylinder to the reservoir are closed. When the piston is carried vertically by the movement of the clutch magnet, the liquid in the reservoir is drawn into the cylinder by suction through valve "n." When the signal blade comes to rest in its position of caution or clear, if the holding

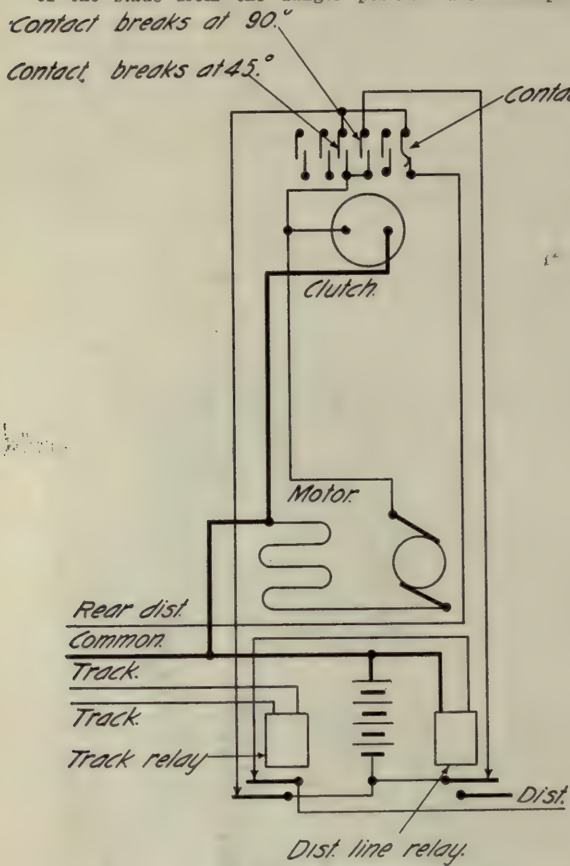


Fig. 567. Operating Circuit of Style "H" Mechanism.

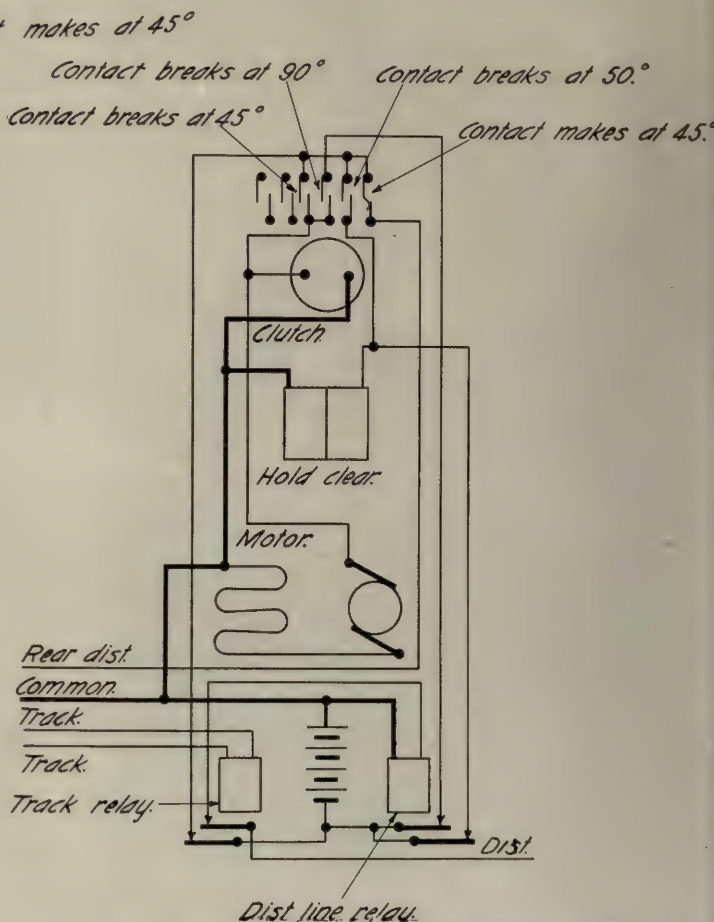


Fig. 568. Operating and Holding Clear Circuit of Style "H" Mechanism.

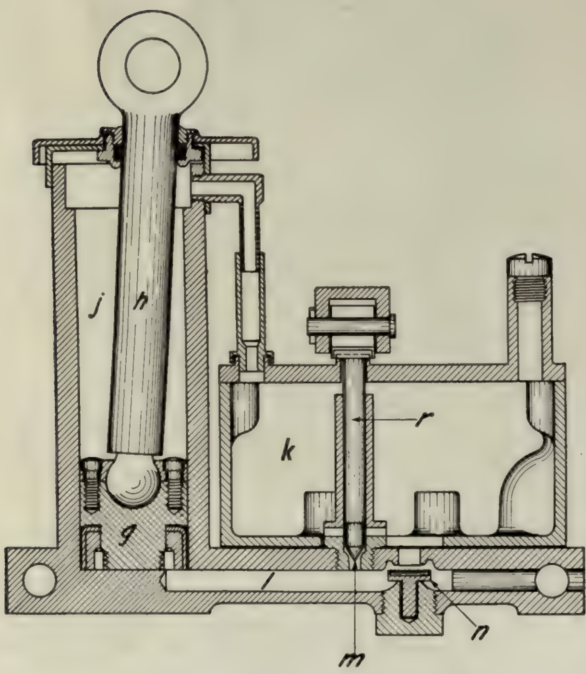


Fig. 569. Details of Oil Cylinder of Hold-Clear Mechanism.

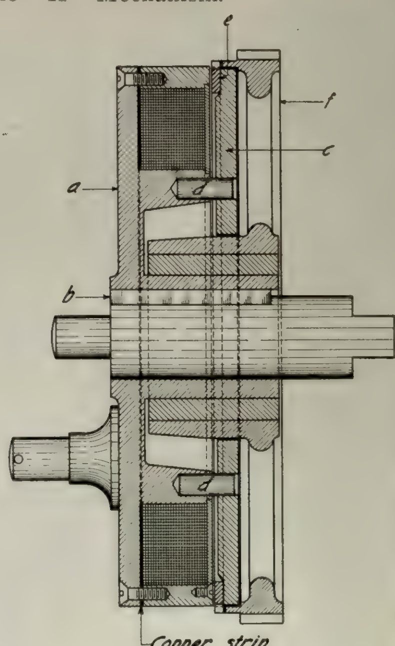


Fig. 570. Details of Gears and Clutch Ring of Style "H" Signal.

magnets are energized and valve "m" accordingly closed, the weight of the signal on the piston tends to force the oil back into the reservoir, but in doing so automatically closes valve "n" and the piston is held in its position of rest. A further movement of the piston repeats this operation. The signal is accordingly held clear by the oil in the cylinder.

When the holding magnet is de-energized by the opening of the circuit, valve "m" is opened, and the opening of this valve

Fig. 571. Installation of Style "H" Automatic Signal Mechanism. Hall Signal Company.

provides a free passage for the oil from the cylinder to the reservoir. The size of the opening of valve "m" is adjusted so that the return flow of oil is regulated in such a manner as to permit the blade to return to its normal position with sufficient retardation to prevent jarring the mechanism. The circuit of the complete operating and holding mechanism is shown in Fig. 568.

AMERICAN TOP POST MECHANISM.

Fig. 573 shows the top-post signal made by the American Railway Signal Co. This mechanism operates without a dashpot and without any mechanical latch. The revolving wheel carrying the fan blades acts as a dashpot, while the rim of the wheel is the armature for the slot coils, holding the blade in its positions by means of tractive force only. No adjustment

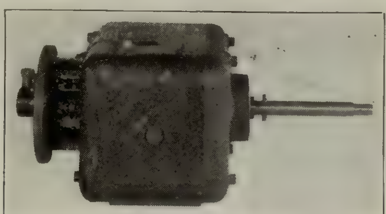


Fig. 572. Top Post Signal Motor. American Railway Signal Company.

is to be made between the rim of the wheel and the slot magnet. The cores of the slot coils extend over the rim of the large wheel and are provided with rings considerably larger than, and free to run on, the cores. These, through magnetic attraction, grip the armature, holding the blade in the proper signal position. When the current is cut off the slot coils, the rings are de-energized, allowing the wheel to revolve by the weight of the blade, and the fan, acting as a dashpot,

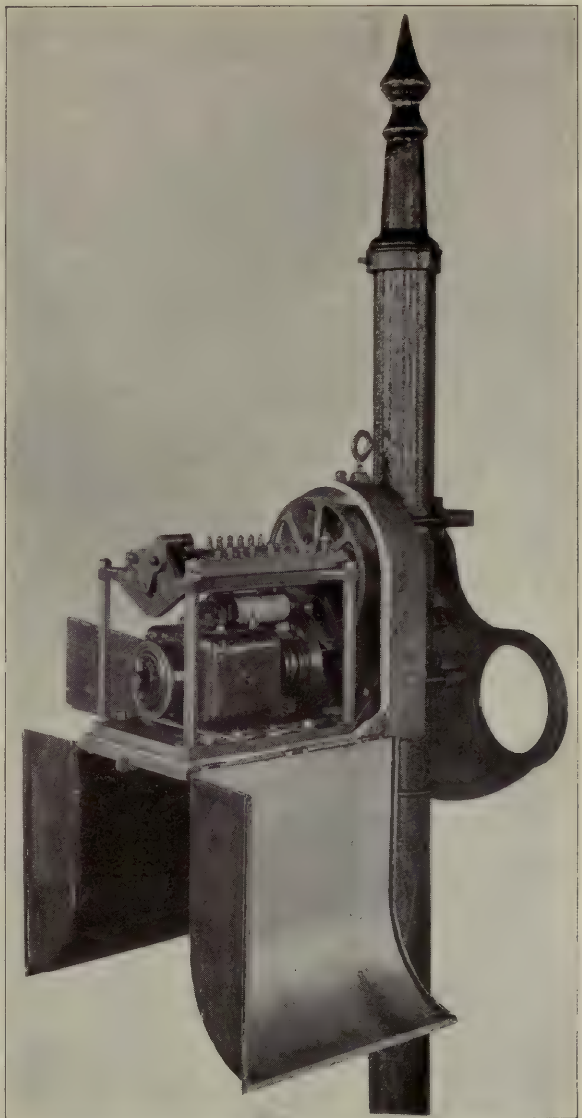


Fig. 573. Top Post Signal Mechanism, Cover Down. American Railway Signal Company.

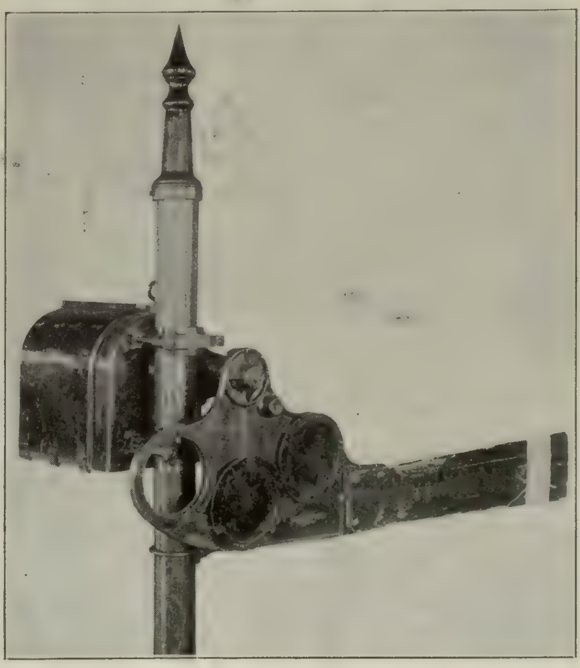


Fig. 574. Top Post Signal. American Railway Signal Company.

not only prevents the jar to the blade when it reaches the horizontal position, but also drives out the accumulated dead air from the case, keeping the mechanism dry and free from moisture. This signal will operate in two or three positions and in the upper or lower quadrant. The case is water-tight and admits of all parts being exposed to view. Condensation is reduced to the practicable minimum.

AMERICAN BASE-OF-MAST MECHANISM.

Figs. 575-576 illustrate the two-arm electric motor mechanism made by the American Railway Signal Co. The distinguishing feature of this mechanism is the use of a revolving fan instead of a dash-pot for preventing shocks when the signal moves by gravity to the stop position. This fan also causes a circulation of air in the case, tending to prevent the accumulation of frost and ice on the moving parts. While the motor is engaged, the fan remains idle, adding nothing to the work of the motor. The same mechanism can be used to operate a one-arm signal for either two or three positions; or a two-arm signal for either two or three positions, the arms to be moved separately or both at the same time, and the arms may be moved in either the upper or the lower quadrant. The arm may be stopped at any angle and immediately returned to the position giving the desired signal indication without first going to the stop position. The circuit controller is enclosed in a water-tight case. With this mechanism the signal is pulled to the clear position so that the vertical rod need not be so heavy and stiff as where the signal is cleared by pushing the rod upward. The motor is enclosed in a dust-proof case, with a glass covering over the commutator. The clutch which causes the motor to engage with the gears is operated by a magnet which is in series with the motor. This clutch is enclosed in a water-tight iron case bolted to the underside of the plate supporting the motor, and it acts through vertical rods, which may be seen at each side (Figs. 575-579) projecting through the base plate. The object of the clutch is to cut the motor clear of the mechanism as soon as the arm has been brought to the clear position. The mechanism operates the arm by means of a quarter inch phosphor bronze rod of 2,100 lbs. tensile strength. The signal is held clear by means of clutch magnets, seen at the top of the illustrations. These magnets are protected from moisture or dirt dropping from above by bell-shaped shields. When the signal goes to the stop position it causes the whole mechanism, except the motor, to revolve backwards; and the weight and friction of the parts suitably modified by the fan serve to provide the necessary cushioning to prevent any shock when the signal arm comes to its normal position.

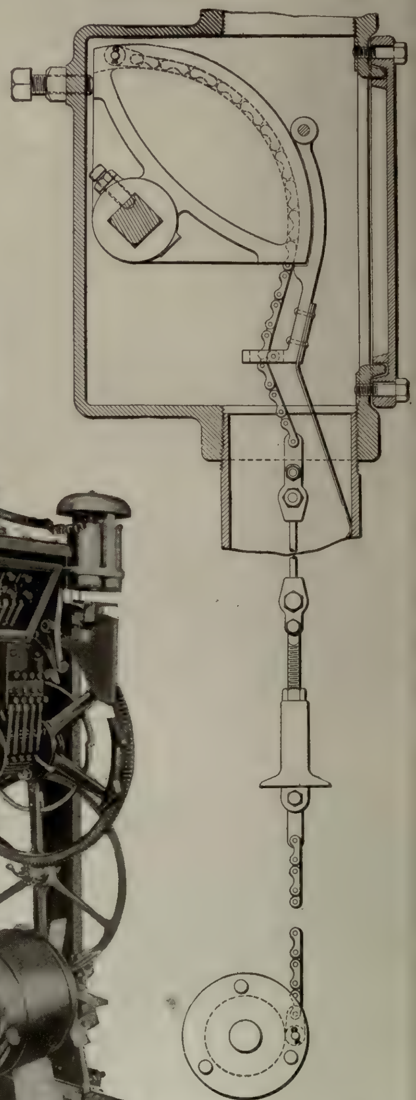
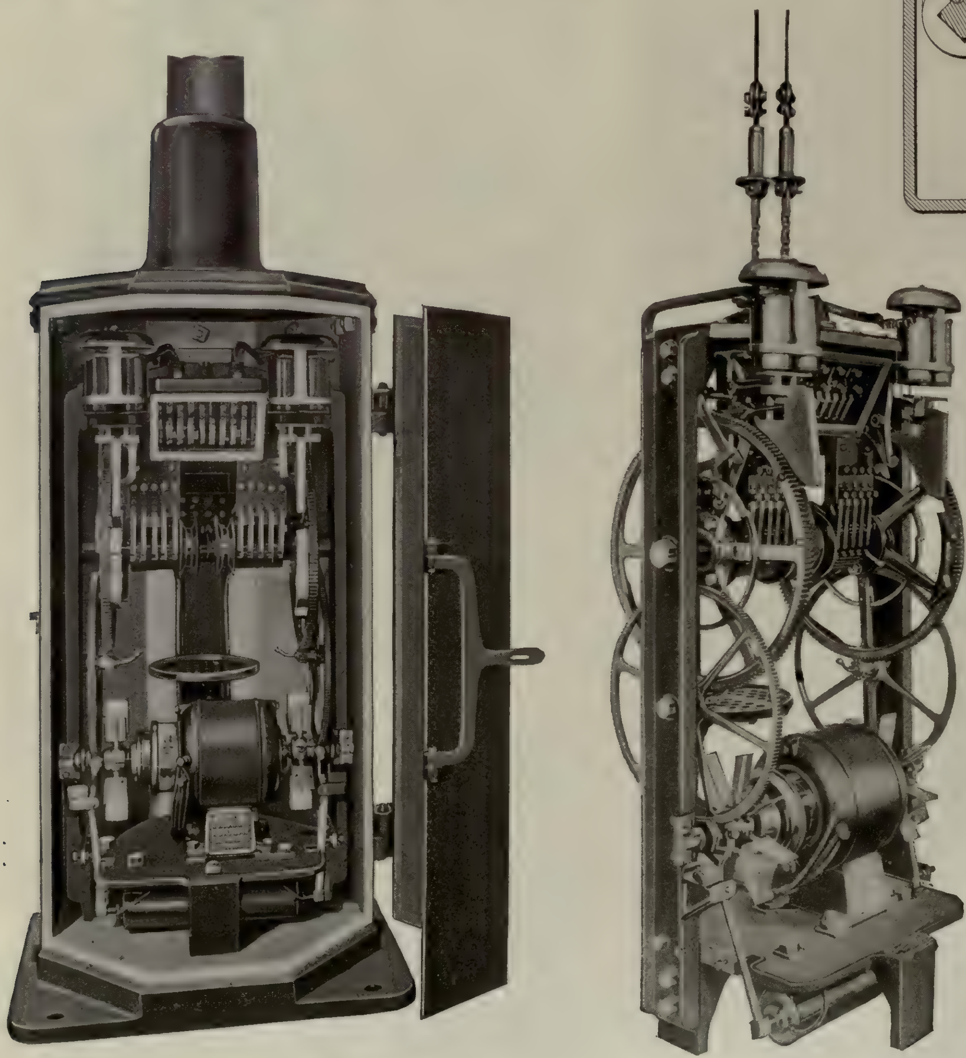
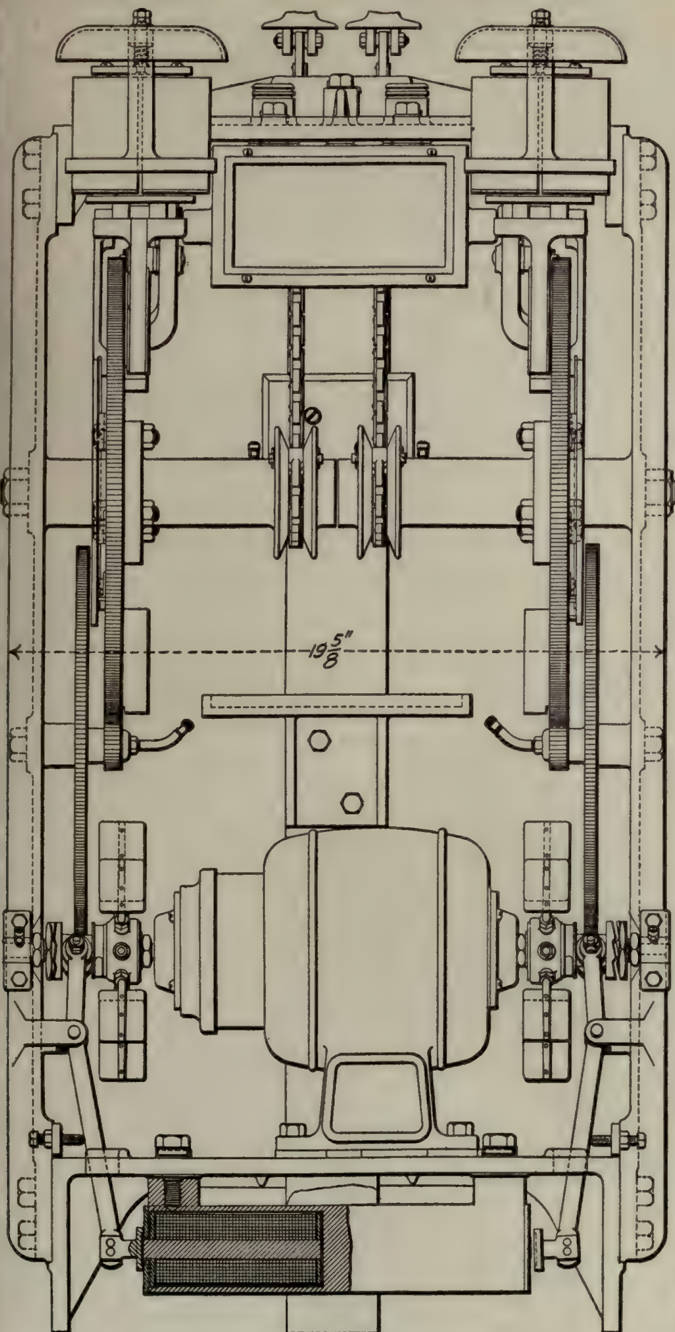


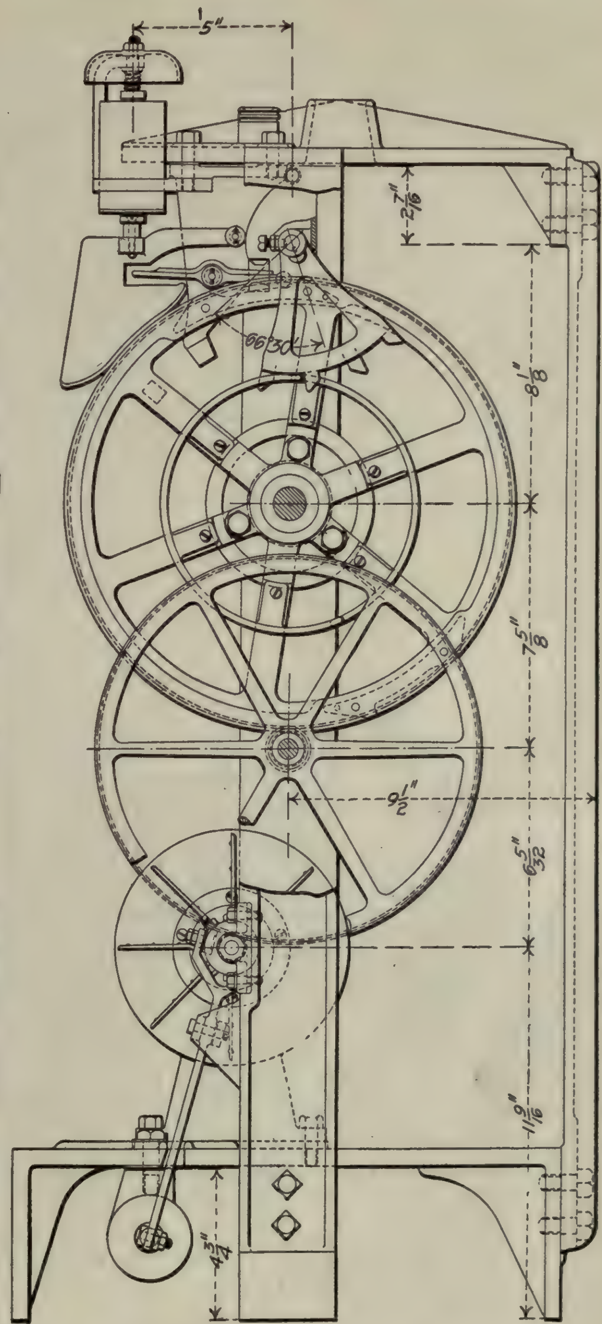
Fig. 577. Mechanical Semaphore Lock on Base-of-Mast Signal Mechanism.



Figs. 575-576. Mechanism for American Railway Signal Company's Semaphore Signal.

Fig. 577 illustrates the connection of the operating rod or chain to the semaphore shaft, the signal and arm being now in the stop position. The chain lies in a groove in the sheave. Having been slackened, to permit the arm to assume this position, it has been forced in toward the shaft so that it does not hang in a straight line. It is kept in this position by the flat spring attached to the lock dog, and the lug on the lock dog prevents the shaft from being turned. When power is applied to the chain it is pulled taut, and this throws the dog clear of the sheave.



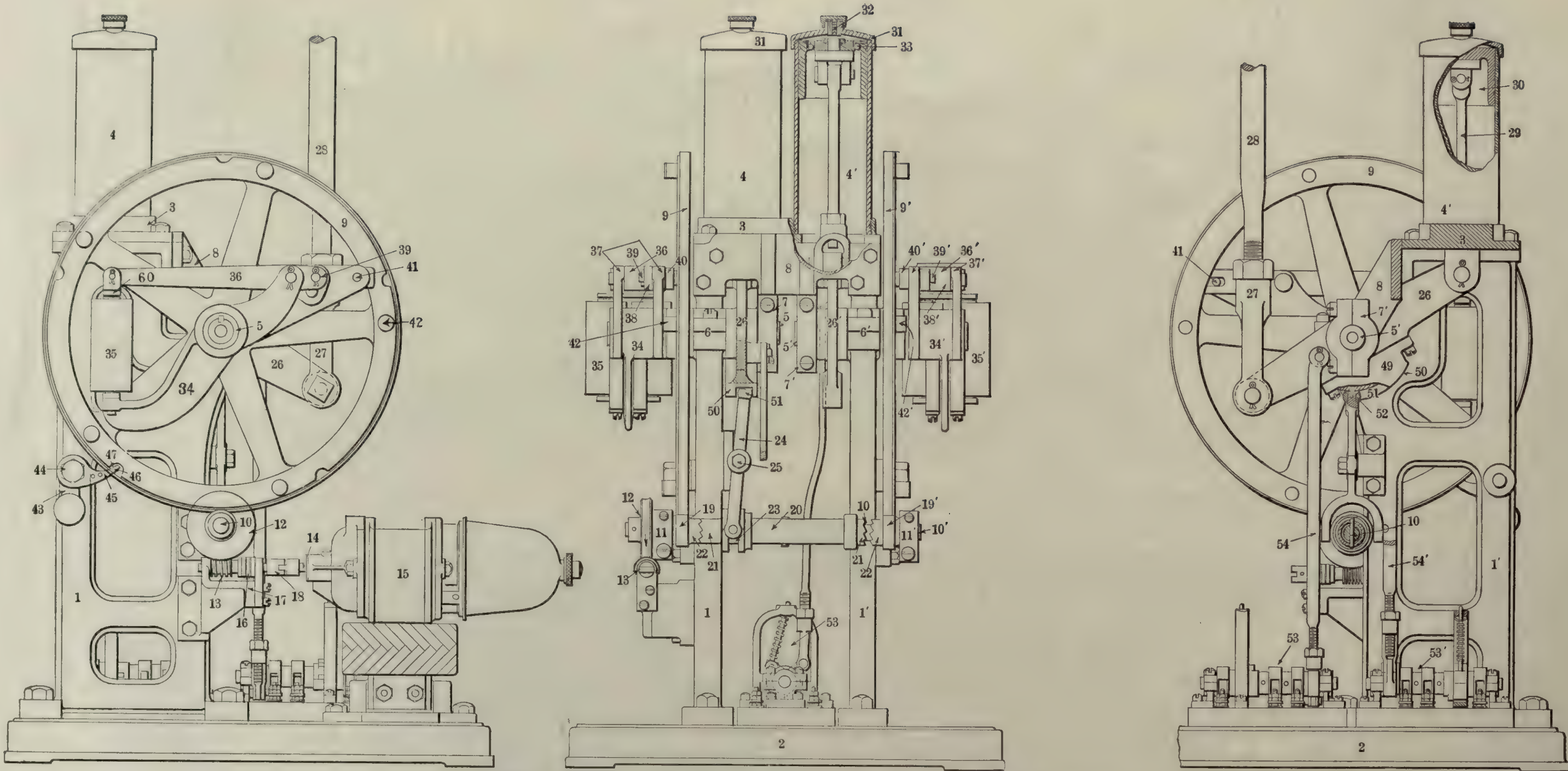


Figs. 578-579. American Railway Signal Company's Base-of-Mast Electric Semaphore Signal Mechanism.

FEDERAL MECHANISM.

The signal mechanism made by the Federal Signal Co. is arranged to operate either one or two arms. It is composed of the two upright stands 1 and 1′ (Fig. 580) which are securely bolted to base 2. These frames are connected at the top by the buffer base casting on which are mounted the buffer cylinders 4 and 4′. Two main shafts or spindles 5 and 5′ turn in bearings 6 and 6′ formed in the frames 1 and 1′, additional bearings 7 and 7′ are formed in the bracket 8 which is bolted to the frame 1 and 1′ and acts also as a tie for the frames. The shafts 5 and 5′ turn in bearings 7 and 7′. On the outside of the frames 1 and 1′, mounted on the shafts 5 and 5′, are the main driving gear wheels 9 and 9′. A shaft or spindle 10 is mounted in bracket bearings 11 and 11′, which are secured to frames 1 and 1′, respectively. Upon this shaft 10 is secured the worm wheel 12 which meshes with and is driven by the worm 13 on the shaft 14 of the motor 15. Bracket support 17 carries a thrust bearing 16 for the worm 13. The flexible connection 18 in the motor shaft 14 is employed to relieve the motor from any friction due to the thrust of the worm 13. On the shaft 10 are loosely mounted the pinions 19 and 19′ which mesh with the gear wheels 9 and 9′ respectively. A clutch sleeve 20 is also fixed to the shaft 10 and turns with it, but is also arranged to slide from side to side. This is accomplished by a slotted hole in the sleeve 20 and a pin in the shaft 10. On the extreme ends of the sleeve 20 are cut notches or teeth 21 and 21′ which engage with similar teeth 22 and 22′ of the pinions 19 and 19′. A grooved collar 23 is formed in the sleeve 20 and is operated by the lever 24, which is riveted at 25 on the frame 1. On the spindles 5 and 5′ between the bearings 6 and 7 and 6′ and 7′ are secured the operating cranks 26 and 26′. To one end of each of these cranks are connected jaws, as shown at 27, to which are attached the up and down rods 28. The opposite ends of the cranks 26 and 26′ are connected by the rod 29 to the buffer piston 30. On the lower edge of the crank 26 is bolted a lug 49, in the curved face 50 of which is cut a cam groove 51. This groove, when rotated, forces the end 52 of the lever 24 from right to left. This operates the clutch sleeve 20 from left to right, thus disengaging it from the pinion 19 and engaging it with the pinion 19′. The caps 31 and 31′ of the buffer cylinders 4 and 4′ are fitted with adjustable air vents 32, and the pistons 30 and 30′ are fitted with ball valves 33, which open and allow the air to enter the cylinders 4 and 4′ during the downward stroke of the pistons and close to prevent the air from escaping back through the pistons during their upward stroke.

Outside the main gears 9 and 9′ on the shafts 5 and 5′



Figs. 580-582. Motor Signal Mechanism. Federal Signal Company.

Names of Parts of Figs. 580-582.

1	*Frame Uprights*	12	*Worm Wheel*	23	*Collar*	34	*Magnet Support*	45	*Tooth of Pawl*
2	*Base*	13	*Worm*	24	*Clutch Lever*	35	*Slot Magnet*	46	*Tooth of Pawl*
3	*Buffer Base*	14	*Motor Shaft*	25	*Rivet*	36	*Armature Lever*	47	*Depression in Wheel*
4	*Buffer Cylinders*	15	*Motor*	26	*Operating Cranks*	37	*Lugs*	48	*Edge of Wheel*
5	*Main Shafts*	16	*Thrust Bearing*	27	*Jaw*	38	*End of Lever* 36	49	*Lug*
6	*Main Shaft Bearings*	17	*Bracket Support*	28	*Up-and-Down Rod*	39	*Pin*	50	*Face of* 49
7	*Main Shaft Bearings*	18	*Flexible Connection*	29	*Buffer Piston Rod*	40	*Link*	51	*Cam Groove in* 50
8	*Bracket*	19	*Pinions*	30	*Buffer Pistons*	41	*Pivot Pin*	52	*End of* 24
9	*Main Gear Wheels*	20	*Clutch Sleeve*	31	*Buffer Cylinder Cap*	42	*Roller Stud*	53	*Circuit Controller*
10	*Clutch Spindle*	21	*Clutch Teeth*	32	*Adjustable Vent*	43	*Counterweight Pawl*	54	*Circuit Controller Operating Rod*
11	*Clutch Spindle Bearings*	22	*Pinion Teeth*	33	*Ball Valve*	44	*Pivot Stud*	60	*Armature*

are secured the magnet supports 34 and 34′ on which are bolted magnets 35 and 35′, supporting armatures as shown at 60. Armature levers 36 and 36′ are pivoted to lugs 37 and 37′ of the support 34 and 34′. The short ends 38 and 38′ of the levers 36 and 36′ connect by pins 39 and 39′ with the long ends of the links 40 and 40′ which are pivoted on pins as shown at 41. The short ends of the links 40 and 40′ project outward toward the periphery of the main gears 9 and 9′ in the path of the roller studs 42. These studs are situated on the sides of the gears, and as many as are required may be used. A counterweight pawl 43 is attached to the frame 1 by pivot stud 44. The tooth 45 of the pawl rests at certain times between the teeth of the gear wheel to prevent the wheel 9 from revolving backward. Another tooth 46 is also fixed to the side of pawl 43; this tooth is somewhat longer than the tooth 45 and normally rests in one of the notches 46 which are formed in the edge of the rim of the gear 9. This edge 48 is formed by reducing the face of the gear 9 to a depth even with the bottom of the teeth of the gear. Circuit controlling devices 53 and 53′ of a quick break type are fastened to the base 2 and are connected to and operated by the cranks 26 and 26′ through the rods 54 and 54′.

If the top or home arm is to be cleared the coils of magnet 35 are energized by closing a circuit from a source of energy. The magnet will hold the armature 60 against its poles and thus maintain the lever 36 and the link 40 rigidly in the position shown. If current be now applied to the motor 15 its armature will revolve and through the medium of its shaft 14 and clutch 18 will cause worm 13 to revolve, which will, in turn, rotate worm wheel 12 and shaft 10. Shaft 10 in turning will revolve the pinion 19 through the medium of the sleeve 20, the left-hand teeth of which engage with the teeth of the pinion 19. The pinion 19 meshing with the main gear 9 which is loosely mounted on the shaft 5 will now revolve, and one of the studs 42 which are mounted thereon will strike against the projecting end of the link 40. In so doing the magnet arm 34, which is rigidly attached to shaft 5, will be partially revolved, turning shaft 5 with it and also crank 26, which is also rigidly attached to the shaft. Crank 26 in swinging will lift the up and down rod 28 sufficiently to move the signal blade the required distance. At this point the circuit controller 53, which is actuated by the crank 26, will cut off the current from the motor 15, but not from the magnet 35. The crank 26 will also actuate the shifting lever 24 and throw the clutch sleeve over from left to right, disengaging pinion 19 and engaging pinion 19′.

While gear 9 has been revolving the tooth 46 of the pawl 43 has been resting against the surface 48 of the gear 9, thus holding the tooth 45 out of engagement with the teeth of gear 9. At the same instant, however, that the clutch sleeve 20 is released from pinion 19, the notch 47 in the edge 48 of the gear 9 arrives at a point adjacent to the tooth 46 of the pawl, thus allowing the pawl to swing and its tooth 45 to engage with the teeth of gear 9, arresting any backward movement of the gear. The signal arm thus cleared will remain so as long as magnet 35 remains energized. If the lower or distant arm is to be cleared the motor 15 is again energized by a circuit through the distant controller 53′ and magnet 35′. The clutch sleeve 20 being now in engagement with the pinion 19′ will cause the pinion to revolve, transmitting its rotary motion to the main gear 9′, clearing the distant signal in the same manner as the home signal was cleared.

Upon the de-energization of the magnets 35 or 35′ the respective signals will, on account of their counterweight, return to stop without turning backward either of the gears 9 or 9′. This is accomplished as follows: When the armature 60 is released, the weight resting on the lever 26 will cause the lever 36 and link 40 to hinge or toggle at point 39, this toggling will withdraw the projecting end of link 40 from its point of contact with the roller stud 42 and allow the crank 26 to come to rest. This returning movement is retarded by the buffers 4 or 4′. The distant signal in going back to normal position does not in any way affect the clutch sleeve 20, which still remains in connection with pinion 19′. Therefore, if the distant section of track governed by this signal be occupied and vacated the signal will automatically return to its normal position and then clear again without affecting the home mechanism. If, however, the home section should be occupied the home signal would return to stop position, and in so doing would throw back the clutch sleeve from pinion 19′ to pinion 19, thus rendering it impossible to clear the distant signal again until the home section was vacated and the home signal cleared. This apparatus can be made, if desired, to operate a single signal by leaving off the right-hand portion of the mechanism.

THE ELECTRO-GAS MECHANISM.

Figs. 583-586 illustrate the two-arm electro-gas signal mechanism made by the Hall Signal Co. Single arm mechanisms are similar to these, except that they have only half as many moving parts. In Fig. 585 one-half of the mechanism is shown in the position for a clear indication and the other half for the stop indication. The controlling power of this signal is electricity, the operating power liquefied carbonic acid gas. The gas, stored in an iron cylinder (Fig. 587) at the foot of the signal post, is normally at a pressure of from 600 to 1,200 lbs. per sq. in., and for use is reduced through a regulating valve (Fig. 588) to from 40 to 60 lbs. pressure per sq. in. Pipe 27, Fig. 585, leads to the mechanism from the main receptacle. The signal rod which operates the semaphore arm is connected to the clamp 31, attached to the cylinder rod, and the gas when admitted to the cylinder 1 causes the cylinder and its rod to move upward and the arm to assume the clear position. The cylinder is movable and its piston is fixed. The flow of gas into the cylinder and its egress therefrom are controlled through valves 9-10, Fig. 584 (shown enlarged in Fig. 589), which in turn are controlled

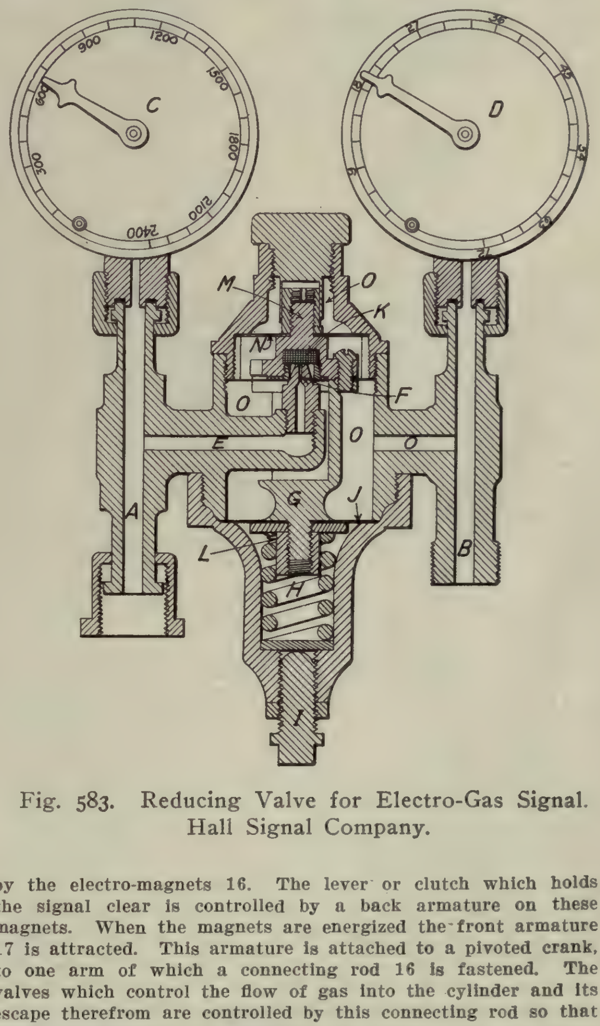


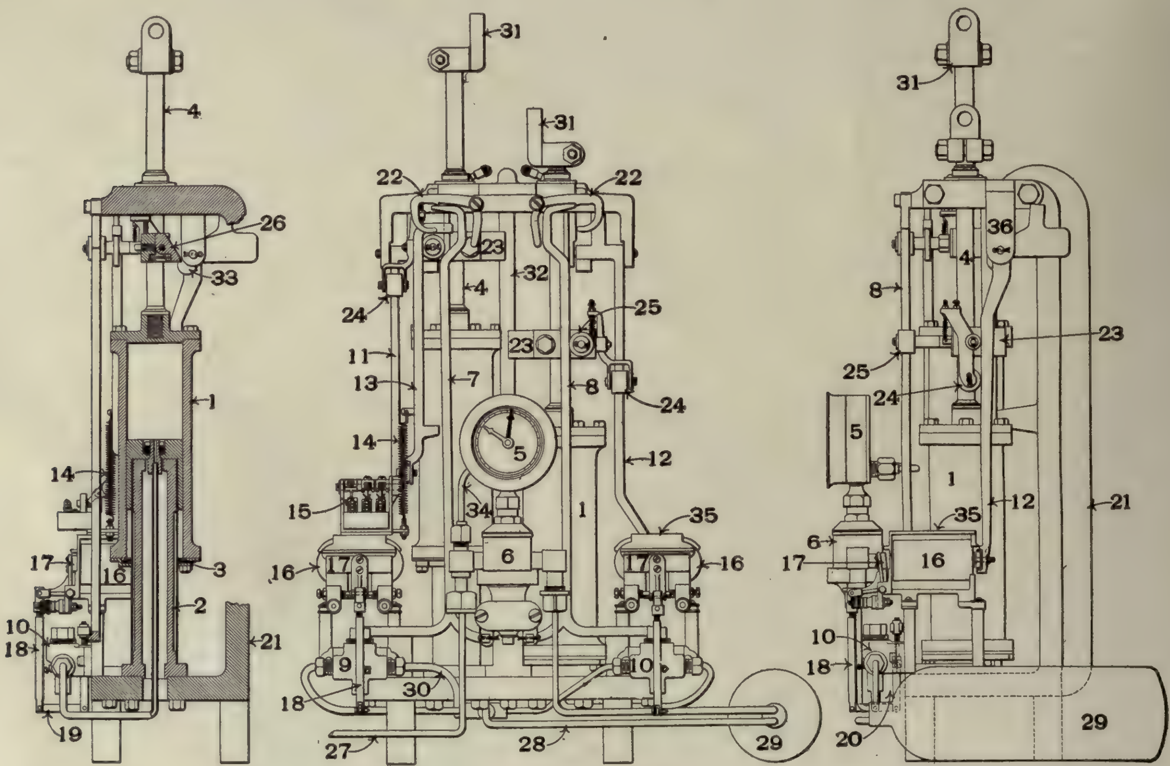
Fig. 583. Reducing Valve for Electro-Gas Signal. Hall Signal Company.

by the electro-magnets 16. The lever or clutch which holds the signal clear is controlled by a back armature on these magnets. When the magnets are energized the front armature 17 is attracted. This armature is attached to a pivoted crank, to one arm of which a connecting rod 16 is fastened. The valves which control the flow of gas into the cylinder and its escape therefrom are controlled by this connecting rod so that when the armature is attracted the supply valve is opened and the exhaust valve closed, which makes a free path for the gas from the tank to the cylinder. This path from the gage and regulator 5-6 is through the expansion chamber and its connection 29, through the valve 9, which has been opened by the movement of the armature, through tube 30 to the inside of the cylinder 1. The pressure causes the cylinder to move upward on its piston and clear the signal. Clutch casting 23 is clamped to the cylinder rod and moves with it along the guide 32. Roller stud 25, screwed into the clutch casting 23, moves along cut-off lever 8 until it raises pawl 22, which is pivoted on a stud screwed into the frame 21. Cut-off lever 8 is shaped like an inverted T and is pivoted on its left leg at the bottom. The right leg is connected to one end of the link 20. The cut-off lever is counterweighted, so that when free to move on its pivot it will force the link 20 down and close the supply valve. At the same time the exhaust valve will be opened, as the two valves are connected, and any movement which closes one opens the other. As soon as pawl 22 has been raised by roller 25, cut-off lever 8 is released, closing

the supply valve, which stops the flow of gas into the cylinder and opens the exhaust valve and allows the gas which has been used in the cylinder to escape.

It is apparent that the gas has been used only to raise the cylinder, not to hold it in its new position. This latter function is performed by the clutch lever 12, which is suspended on pivoted bearing 36. The top of this lever has a nose-shaped projection which engages a latch on the back of clutch casting 23. The lower end of clutch lever 12 carries an armature for magnet 16, and when the magnet is energized the clutch lever is held in such a position that the latch on casting 23 rests on the nose of clutch lever 12 and holds the signal in the

Fig. 589 shows the controlling valves (9-10, Figs. 584-586) in detail. Parts 18-19-20 are the same as those of corresponding number in Figs. 585-586. Adjustable connections N and B are attached to the front armature and to rod 7 or 8. The body of the valve E has a cover H; K is the valve itself, with stem connected to C, and L is the valve guard and seat; F is a washer; D is a steel ball serving as a check to retard the exhaust of gas from the cylinder so as to form a cushion between the cylinder head and the piston. D is kept from completely blocking the passage by adjusting screw A. Gas is admitted at the left and passes up and over L. When K is raised from its seat, C seats at O and gas passes around



Figs. 584-586. Hall Electro-Gas Signal Mechanism for Two-Arm Signal Mechanism.

Names of Parts of Hall Electro-Gas Two-Arm Signal Mechanism. Figs. 584-586.

1 *Cylinder*
2 *Piston*
3 *Cylinder Packing*
4 *Operating Rod (Cylinder Rod)*
5 *Pressure Gage*
6 *Regulator*
7 *Cut-off Lever, L. H.*
8 *Cut-off Lever, R. H.*
9 *Gas Valve, L. H.*
10 *Gas Valve, R. H.*
11 *Clutch Lever, L. H.*
12 *Clutch Lever, R. H.*
13 *Circuit Closing Rod*
14 *Circuit Closing Rod Spring*
15 *Circuit Closer*
16 *Valve Magnet Coils*
17 *Valve Magnet Armature*
18 *Valve Connector*
19 *Valve Lever*
20 *Valve Lever Adjusting Link*
21 *Frame*
22 *Cut-off Lever Pawl*
23 *Clutch Casting*
24 *Buffer Lever Roller*
25 *Cut-off Lever Roller*
26 *Clutch Casting Latch*
27 *Tank and Regulator Connection*
28 *Expansion Chamber Connection*
29 *Expansion Chamber*
30 *Cylinder Connection*
31 *Signal Rod Clamp*
32 *Clutch Casting Guide Rod*
33 *Clutch Casting Catch*
34 *Gage Connection*
35 *Valve Magnet Cover*
36 *Clutch Lever Shaft Support*

clear position. When the magnet becomes de-energized clutch lever 12 is released and the counterweight of the signal, falling, causes clutch lever 12 to fly backward on its pivot 36 a sufficient distance to allow the latch and clutch casting 23 to pass the projection on the clutch lever 12; and the signal drops to the stop position. The escape of the gas or air from the cylinder through the exhaust valve is so regulated that the piston and cylinder become a dash-pot, preventing any violent drop of the cylinder when the signal assumes the stop position. Circuit breaker 15, used to control the distant and other circuits, is shown in Figs. 527-528. It is operated by rod 13 through a crank. The upper end of rod 13 is bent at right angles and has a lug, as shown. Roller 25 moves 13 up by striking against the bent top or down by striking the lug. Spring 14 will pull 13 down in case the lug should break. Cut-off lever 7 is left-handed and 8 is right-handed, and the same is true of 11 and 12.

The piston and cylinder are made of phosphor-bronze, ground to a true fit. The cylinder being inverted and moving on the piston, it can have a solid head, certainly preventing the entrance of water. Its pedestal has a brass bushing.

K and D to the cylinder. When C is lowered K seats and is held seated by the pressure of the gas. The exhaust passes from the cylinder, around D and down around the stem of K and C to the atmosphere.

Fig. 583 is an enlarged view of the regulating valve 6, Figs. 584-586, though in those illustrations only one gage is shown instead of two. The single gage has two hands, one for the high pressure and one for low. It is mounted centrally and a pipe leads to it from the coupling where the high pressure gage is mounted in Fig. 585. The functions of the various parts and the operation of the valve are as follows: Gas enters the valve body through E, which is connected to the high pressure gage C, and reaches valve seat F. Before the gas is turned on, the adjusting screw I is unscrewed so that there is no pressure on the spring H; then the diaphragm J tends to hold the hard rubber valve disk K down on the seat F, and when the gas is turned on prevents it from escaping to any extent. Then the adjusting screw I is screwed in. This puts pressure on spring H. The top of this spring bears on the flange L and raises it, with all the parts connected to it, which includes the center of the diaphragm J,

the support for disk holder G, the disk holder M with the disk K and the center of the slotted diaphragm N. This operation raises the hard rubber disk K off the seat F and allows the high pressure gas to flow into the chamber O. The gas continues to flow into the chamber O and fills the passage leading to the low pressure gage D, which indicates the pressure. It flows through the pipe leading to the expansion chamber, 29, Fig. 448, which is connected at B. If the valves of the signal mechanism are closed the gas pressure gradually increases in O and the expansion chamber until it becomes great enough on the diaphragm J to force it down and compress spring H. When the diaphragm J is forced down by the gas pressure, the parts attached thereto, including the support for disk holder G, valve disk holder M and the hard rubber valve disk K, move with it. When the hard rubber

dust and prevent injury to the couplings and valves while in transit, and has a safety plug which will blow out if the pressure should become dangerous. One tank holds enough gas for several hundred signal movements. Tanks are shipped as needed from a central manufactory and a reserve tank is kept at each signal post.

Fig. 588 shows the local wiring for an electro-gas mechanism, when used in the normal danger systems shown in Figs. 502-503. It is similar to Fig. 522.

ELECTRO-PNEUMATIC SIGNAL.

This type of signal involves the direct application of compressed air to the signal shaft through the medium of arms thereon, which are connected by short links to the pistons of two cylinders mounted in close proximity to the shaft; two

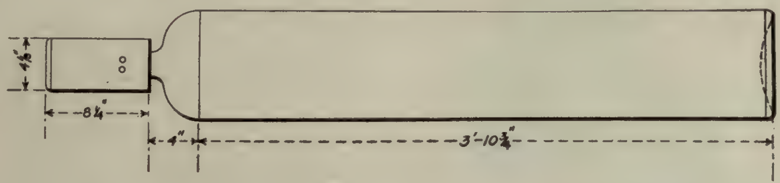


Fig. 587. Standard Flask for Liquid Gas. New York Central & Hudson River.

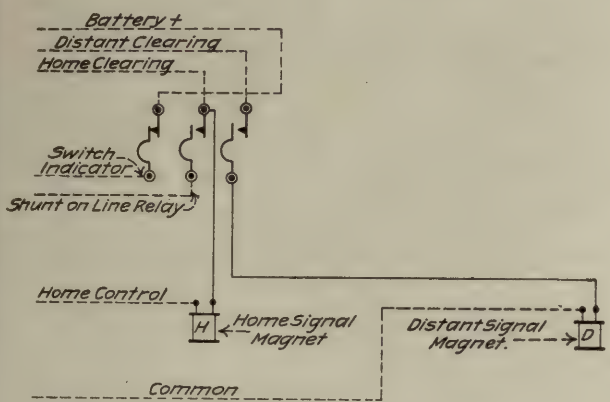
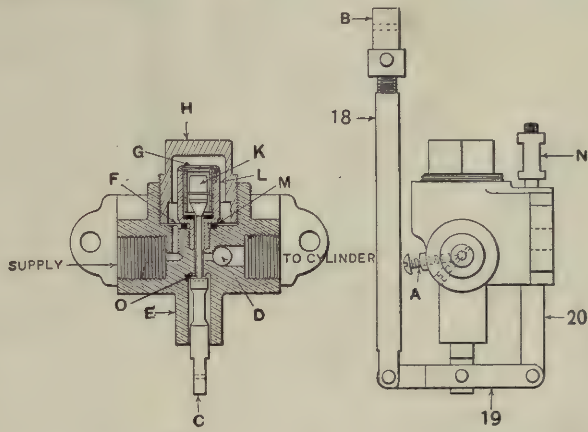


Fig. 588. Wiring for Hall Electro-Gas Automatic Block Signal; Normal Danger, Double Track.



Figs. 589-590. Controlling Valve, Electro-Gas Signal. Hall Signal Company.

valve disk is forced down it bears on the top of the valve seat F and stops the flow of gas. The gas pressure required to stop the flow of gas is determined by the amount of pressure put on the spring by the adjusting screw. If a higher working pressure is required, the adjusting screw I is screwed in further, putting a greater pressure on the spring H, making necessary a higher gas pressure on the diaphragm J to press the hard rubber valve disk K on the seat F and stop the flow of gas. Unscrewing the adjusting screw reduces the pressure on the spring, and the gas has less pressure to overcome in order to move the diaphragm and the parts attached to it; consequently a lower gas pressure stops the flow of gas. Whenever any gas is drawn from the low pressure side of the regulating valve, the pressure is reduced and the spring immediately forces the diaphraghm and parts attached to it up, which raises the hard rubber valve disk off the seat and allows gas to flow into the low pressure side of the regulating valve, thus keeping the pressure on that side practically constant.

The support for disk holder G is rigidly attached to the center of diaphragm J, and the upper end of the support is securely fastened to the valve disk holder M by means of three screws, thus making one rigid piece. The threaded end of the valve disk holder M projects through a hole in the slotted diaphragm N, and a threaded sleeve is screwed down on the slotted diaphragm N, firmly clamping it between the sleeve and the valve disk holder; thus the parts in which the hard rubber valve disk are held are centrally guided at the lower end by the diaphragm which transmits the pressure to the spring, and the upper end is centrally guided by a diaphragm which is slotted to make it flexible, and also to allow the pressure to become equal on all sides of it. By using the two diaphragms to guide the valve disk the disk must always seat in exactly the same place.

Fig. 587 the gas tank, is made of steel to withstand a pressure of 3,000 lbs. per sq. in. It has a cover to exclude

pneumatic valves attached, one to each cylinder, and two electro-magnets, one for the operation of each valve.

The short stroke cylinder causes the movement to the 45-deg. position, and carries the piston of the long stroke cylinder idly to midstroke.

A further movement of the signal toward the 90-deg. position is not possible by the piston of the short stroke cylinder, which has seated when the signal is at 45 deg. upon the packing ring in the lower cylinder head to minimize loss of pressure from escape through the packing rings of the piston.

Movement of the signal from 45 deg. to 90 deg. is effected solely by the long stroke cylinder. Pressure is admitted to this cylinder (with its piston at mid-stroke) through the electro-magnetic valve attached to it, and after operation seats the piston of this cylinder upon the packing ring in its lower head, as in the case of the short stroke piston, to retard pressure losses through the piston rings.

This operation carries the arm upon the shaft by which the signal was moved to 45 deg. by the short stroke cylinder, downward through the slotted end of the piston rod of that cylinder.

By de-energizing the magnet of the valve of the long stroke cylinder the air is permitted to escape from that cylinder and the signal under the influence of gravity returns to the 45-deg. position when the arm on the shaft which engages the slotted piston rod of the short stroke cylinder is arrested in its upward movement by virtue of its having traveled through the slotted part of the piston rod and has a tendency to move that rod with it in the further movement of the signal from 45 deg. to 0 deg. This it will be unable to do if the pressure still remains above the piston and the signal will consequently be retained by the short stroke cylinder at 45 deg.

Should the pressure be released from this short cylinder its piston will move upwards under the signal's weight to the end of its stroke, when the signal will be at 0 deg., or horizontal.

It is characteristic of this signal that the air supply to the

long stroke cylinder is drawn through its valve, not direct from the air main as in the short stroke cylinder, but from the pressure chamber above the piston of the latter cylinder.

This makes it impossible to operate the signal from the horizontal position by the long stroke cylinder, if for any reason its valve should be operated in advance of that of the short

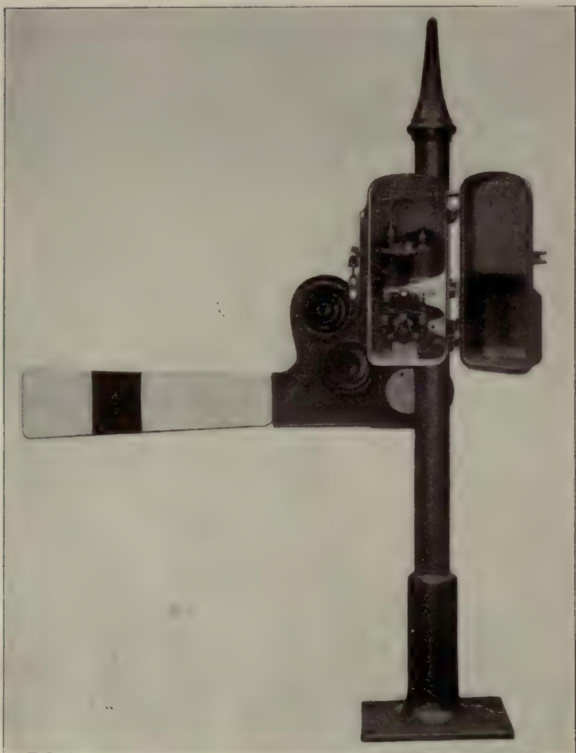
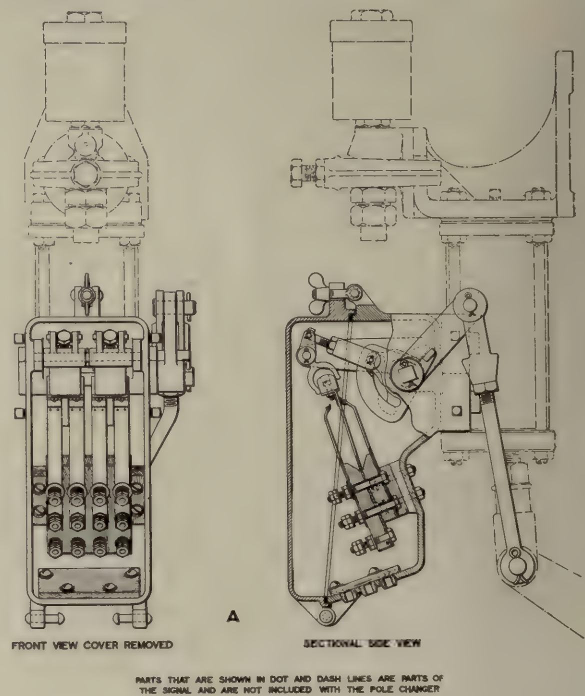


Fig. 591. Electro-Pneumatic Three-Position Top Post Signal.

stroke cylinder; and the control of the valve of the long stroke cylinder electrically by position of the signal when moved to 45 deg. by the short stroke cylinder is not necessary with this system of piping save as a precautionary measure.

This method of piping will permit the signal to move from vertical (90 deg.) to horizontal by de-energization of the magnet of the short stroke cylinder alone and irrespective of the energized state of the valve magnet of the long stroke cylinder, the pressure and exhaust of both cylinders being under the immediate control of the valve of the short stroke cylinder at all times.

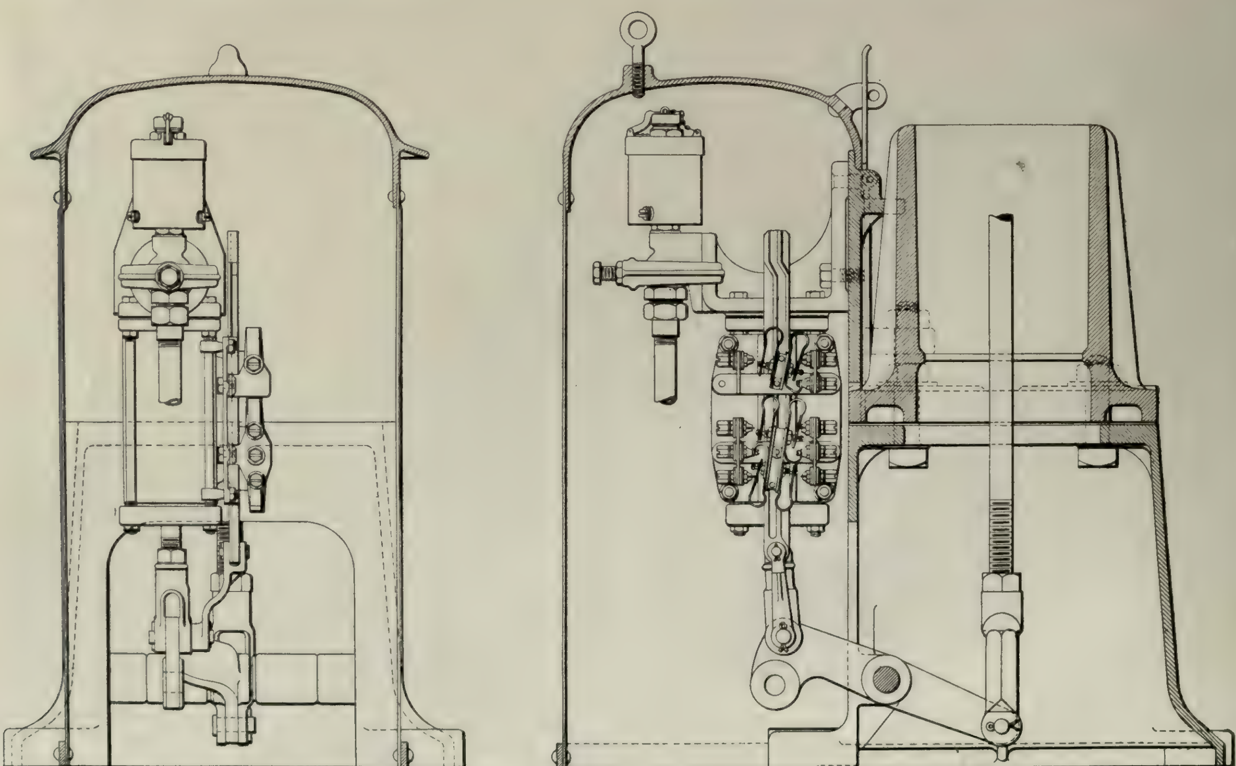
A positively acting circuit controller, easily demountable and accessible to inspection, is attached to the face of the mechan-



Figs. 592-593. Pole Changer and Circuit Controller for Lower Quadrant High Signals.

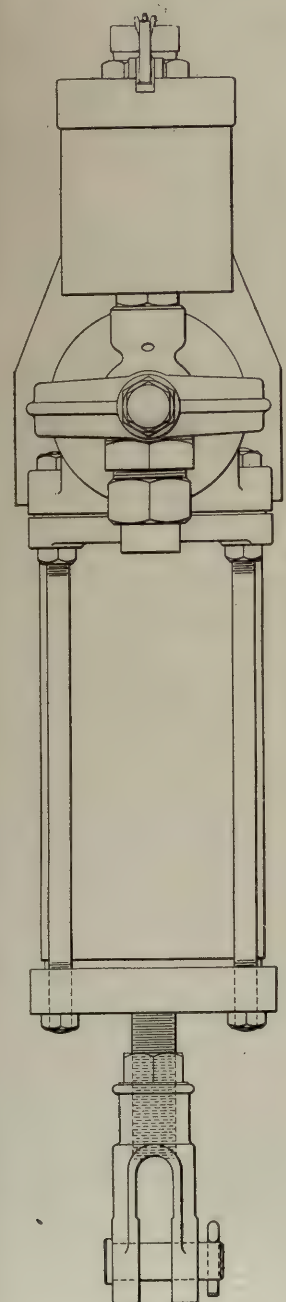
ism case and operated by direct coupling from the semaphore shaft.

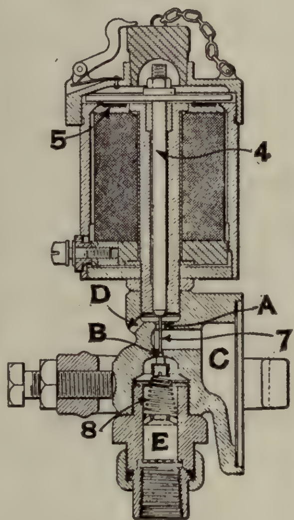
This device is adapted to actuate the contacts at any period of the signal's movement by simply shifting the cams upon the square shaft upon which they are mounted.

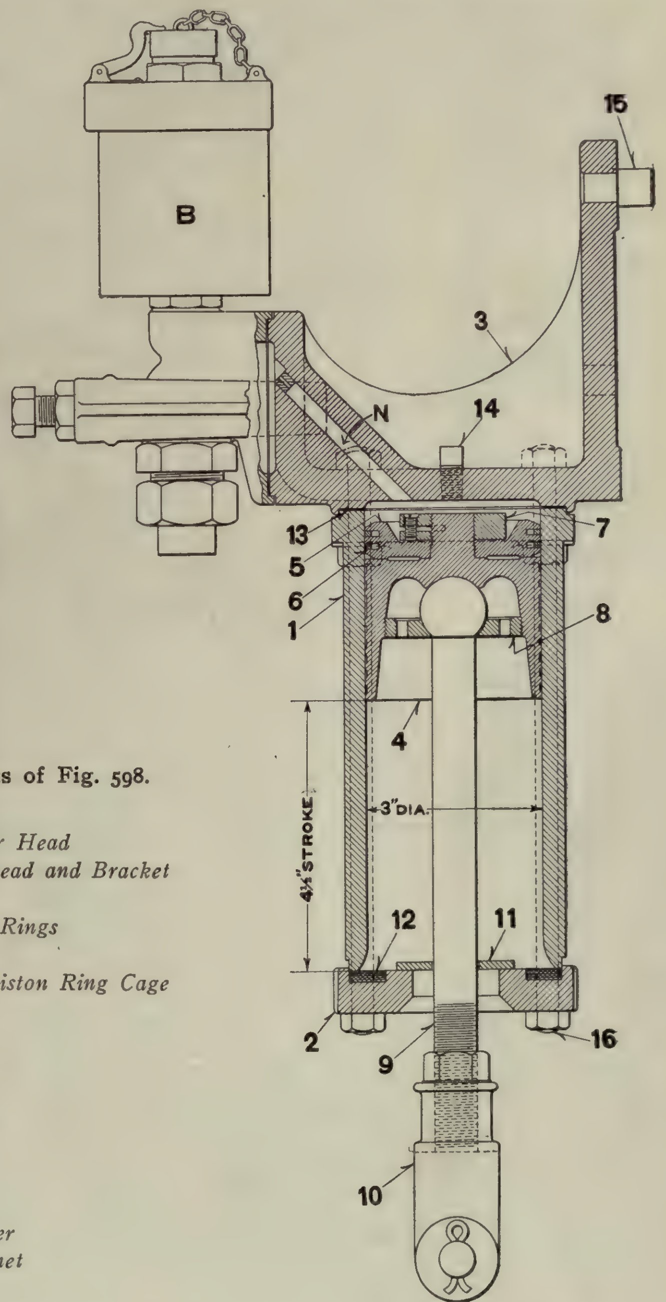


Figs. 594-595. Electro-Pneumatic Signal Mechanism. Union Switch & Signal Company.

Fig. 597 illustrates the pin valve and its magnet used to control electro-pneumatic signals, made by the Union Switch & Signal Co. The magnet is of the "iron-clad" type. Between the pole piece and the armature there is a spring 5, which assists in releasing the armature when current is withdrawn. The stem 4 of the armature passes down through the center of the magnet and rests on the stem, 7, of the pin valve. The armature stem has a beveled end to seat in the opening below when it is depressed. The pin valve is held against its seat, B, by the pressure of the air at E and also magnet, B, and the pin valve. The cylinder, 1, and the bottom head, 2, are bolted to the main head as shown. Piston 4, moving in the cylinder, is forced down by the admission of compressed air at the top and motion is transmitted to the signal by means of the piston rod 9. This is connected to the "up and down rod" of the signal through a balance lever (Figs. 594-595). The piston rod is secured to the piston by a universal ball and socket joint, and disk 8, which is screwed into the piston, forms the lower portion of this joint. Washer 11 rests on the bottom cylinder head and keeps out dirt.







Names of Parts of Fig. 598.

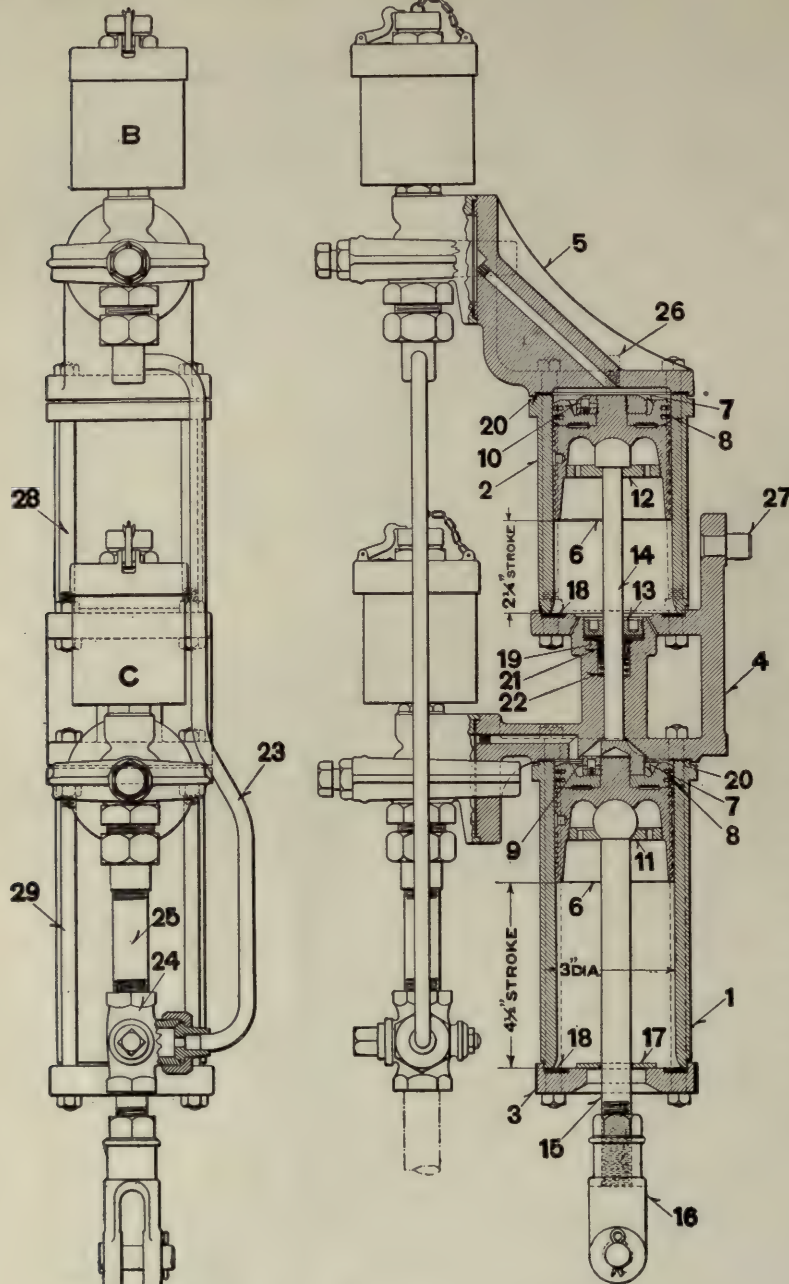
1 *Cylinder*
2 *Bottom Cylinder Head*
3 *Top Cylinder Head and Bracket*
4 *Piston*
5 *Cage for Piston Rings*
6 *Piston Ring*
7 *Lock-Nut for Piston Ring Cage*
8 *Ring Nut*
9 *Piston Rod*
10 *Jaw*
11 *Washer*
12 *Leather Gasket*
13 *Fiber Gasket*
14 *Oil Plug*
15 *Dowel Pin*
16 *Stud for Cylinder*
B *Pin Valve Magnet*

Figs. 596-598. Details of Electro-Pneumatic Cylinder, Magnet and Valve for Semaphore Signal. The Union Switch & Signal Company.

by the spring 8. E is connected to the source of air supply. When the magnet is energized, the armature is attracted and its stem presses down and unseats the pin valve. This admits air to the chamber C. At the same time the end of the armature stem seats at A, so that air cannot escape through the exhaust port D. When the magnet is de-energized the various parts return to their normal position, as shown. This allows air to escape from C to the atmosphere through D and prevents entrance of air from E, through B, to C.

Figs. 596 and 598 show an electro-pneumatic cylinder for a semaphore signal. The cylinder head 3 with its bracket is fastened to the support at 15. To this is clamped the valve When compressed air is admitted to the chamber C (Fig. 597), it passes through the diagonally arranged port N, to the space above the piston and forces the piston down, clearing the signal. When the magnet at B is de-energized, the air is shut off and chamber C is connected to atmosphere through D; the air in the cylinder above the piston escapes, allowing it to assume its normal position, as shown, putting the signal in the stop position. This it does by gravity.

In Figs. 599 and 600 is shown an electro-pneumatic mechanism for operating a three-position semaphore. It consists essentially of two of the ordinary two-arm mechanisms superimposed one upon the other. The upper cylinder is shorter



Figs. 599-600. Electro-Pneumatic Cylinders for Three-Position Semaphore, Tandem Movement.

Names of Parts for Figs. 599-600.

1 *Lower Cylinder*
2 *Upper Cylinder*
3 *Bottom Head for Lower Cylinder*
4 *Bracket*
5 *Top Cylinder Head*
6 *Piston*
7 *Cage for Piston Rings*
8 *Piston Ring*
9 *Lock-nut for Lower Piston Ring Cage*
10 *Lock-nut for Upper Piston Ring Cage*
11 *Ring Nut for Lower Cylinder*
12 *Ring Nut for Upper Cylinder*
13 *Stuffing Box Ring Nut*
14 *Upper Piston Rod*
15 *Lower Piston Rod*
16 *Jaw*
17 *Washer*
18 *Leather Gasket*
19 *Leather Packing*
20 *Fiber Gasket*
21 *Gland for Stuffing Box*
22 *Stuffing Box Spring*
23 *Pipe Connection*
24 *Three-way Cock and Union*
25 *Air Inlet for Lower Cylinder*
26 *Oil Plug*
27 *Dowel Pin*
28 *Stud for Upper Cylinder*
29 *Stud for Lower Cylinder*
B *Upper Pin Valve Magnet*
C *Lower Pin Valve Magnet*

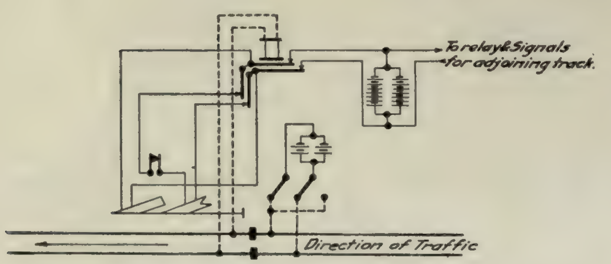


Fig. 601. Wiring for Electro-Pneumatic Automatic Block Signal; Distant Signals Controlled by Polarized Track Circuits; Primary Battery. Pennsylvania Railroad.

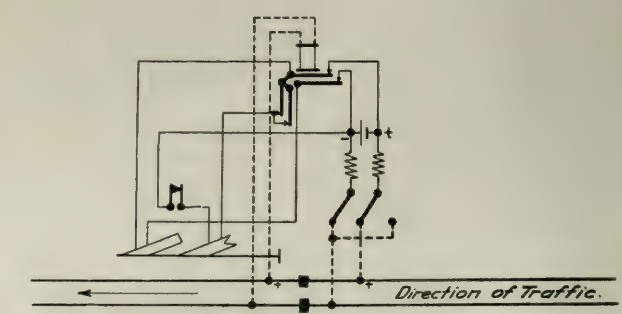


Fig. 602. Same as Fig. 601, but with Storage Battery in Place of Primary.

than the lower. The piston rod of the upper cylinder rests on top of but is not connected to the piston of the lower cylinder. The upper cylinder is used to move the signal through the first half of its stroke, that is, from stop to caution, and the second half is accomplished by the action in the lower cylinder, the piston of which moves away from the upper piston rod. This rod acts as a stop when the signal is returned from the clear to the caution position.

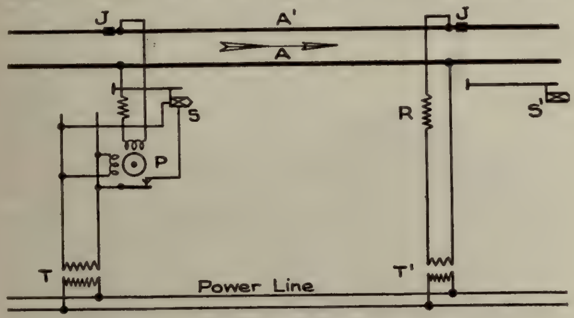
ALTERNATING CURRENT SIGNALING

DISCUSSION.

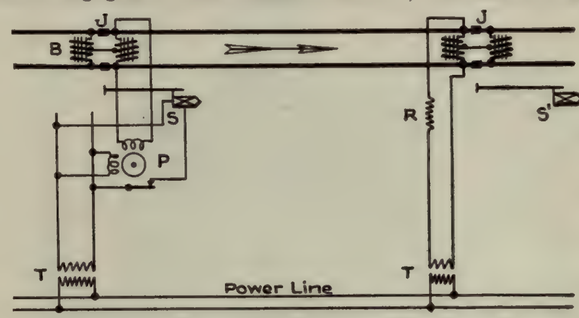
In the signaling of roads employing steam as the motive power the track circuit is comparatively simple (Fig. 484). When, however, the rails are required to carry the heavy currents called for by electric traction, the track circuit problem becomes more difficult.

First: Because the rails must be made electrically continuous throughout to serve as a return for the propulsion current and at the same time must be divided into electrically insulated sections as far as signaling current is concerned.

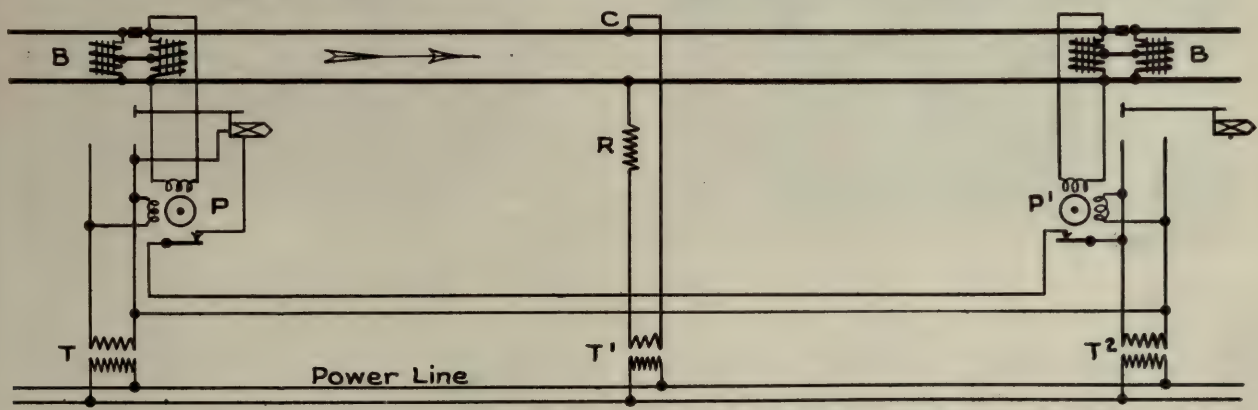
Fig. 603 shows the "single rail" circuit, which is the simplest form of a. c. track circuit, and is only used where it is permissible to give up one of the rails for signaling purposes only. It is best adapted to roads employing direct current for propulsion. The rail A is continuous throughout and is used as a return for the traction current. Rail A′ is insulated at the joints J-J, and is used only for the signaling current. P is an alternating current relay of the two-phase type described above. When both windings are energized the motor revolves, and being geared to the contact closes it, the contact acting



Single Rail Circuit.



Double Rail Circuit. Iron Core Reactance Bonds.



Center Fed Double Rail Circuit. Iron Core Reactance Bonds.

Figs. 603-605. Alternating Current Track Circuits.

Second: Because the traction current flowing in the rails would tend falsely to operate the track relays were they of the usual direct current type; hence, the necessity of employing relays which are unaffected by the traction currents and supplying a signaling current of the right character to operate them.

Third: Because for traction purposes cross-bonding between tracks is necessary at frequent intervals, thus influencing the arrangement of track circuits.

Figs. 603-604 show two types of track circuits, which fulfill the requirements imposed by electric traction. In both of these, alternating current is used for signaling purposes. The track relay (Figs. 607-608 is operated by a small two-phase induction motor, one winding of which is energized through the track rails and the other winding direct from the power line. This relay is not affected by direct current, no matter what frequency, within reasonable limits, is used for signaling and is not affected by alternating current if a frequency distinctively different from that of the traction current is used. For in a two-phase induction motor, if the phase in one set of field coils varies greatly from that in the other, the motor will not operate. As both sets of fields in the two-phase induction motor relay are fed from transformers on the same single-phase power line, some agency must be provided to produce different angles of lag in the two secondary circuits, otherwise the relay would not act. Such agency exists in the different apparent resistances of the line circuit and the track rails. Also in inductive and impeding effects of the rails and bonds. It is not necessary, however, to use two-phase motor relays. Single-phase induction relays will give satisfactory results. But where the track circuit is long and leakage heavy it is better to use two-phase relays, as they have a good torque with a small current from the track. They are more expensive, however, than single-phase relays and add some complication to the wiring.

On account of the fact that alternating current is used for signaling and that either one or both of the rails may be used for the propulsion current return, the circuits are known as "Single Rail a. c. Track Circuits," or "Double Rail a. c. Track Circuits."

as a stop to the movement of the armature, which now ceases to turn, but bears against the contact, holding it closed. The signal S (using current from the transformer T) operates as already described in connection with Fig. 484.

When a train enters the track circuit the current from transformer T′ is shunted out of the relay, as already described in the ordinary direct current track circuit and, although current from the transformer T still continues to flow through one winding, the motor loses its torque, the armature is revolved in reverse direction by gravity and the relay contact opens.

R indicates a resistance so proportioned that the drop in potential in rail A, caused by the flow of traction current, will not cause injurious currents to flow through the relay P, or the secondary at the track transformer T′. (See Boston Elevated description.) The resistance also prevents an excessive flow of current from transformer T′, when a train is standing at the transformer. These resistances are of the non-inductive type. They are constructed of cast-iron grids, and the form of these cast-iron resistance grids is such that current passing through them produces no magnetic effects. The grids are mounted on two or more rods, which are provided with the necessary insulation and can be built up to any desired resistance.

T and T′ are stepdown transformers, which reduce the voltage from the power line to that required for track circuit and other purposes. Cross-bonding for traction purposes may be made at any point on the continuous rail A.

Fig. 604 shows a type of a. c. track circuit, in which both rails are retained for propulsion purposes, but in which cross-bonding to adjacent tracks can occur only at the ends of track circuits. This type of track circuit is especially adapted to roads where the traffic is very heavy and the block of medium lengths; and is applicable to either a. c. or d. c. traction. As shown, both rails are insulated at the signal locations by the joints J and are made continuous as concerns the traction current by the iron core reactance bonds B.

The reactance bonds B consist of a few turns of very heavy copper, wound around a laminated iron core and so connected to the rails that the traction current in each rail

flows through one-half the bond in such manner as to have no magnetic effect unless more current is flowing in one rail than the other, in which case there would be a tendency to saturate the iron core and thus reduce the reactance of the bond. This tendency is, however, limited by an air gap in the

Fig. 606. Universal Model "2-A" Base-of-Mast Signal Mechanism. A. C. Control.

magnetic circuit. This difference of current is called *unbalancing*. This can be better understood if it is noted that propulsion current flows in the same direction in each rail. Therefore the bond is in effect two electro-magnets of equal strength wound on the same cores in opposition. Thus the magnetic effect due to direct current in one winding will neutralize that in the other unless more current should flow in one rail than in the other. If the iron core were continuous the effect of an unbalanced propulsion current would be to shift the neutral magnetic point along the core a distance proportional to the amount of unbalancing. For this reason the air gap is introduced in the magnetic circuit, and the wider the gap the less the neutral point will shift for a given amount of unbalancing because air is a poor conductor of

Fig. 607. Universal Polyphase Relay. Model 2, Form A (6-way).

magnetic lines of force compared with iron. But the wider the air gap is made the lower becomes the inductive effect of the iron (which is a maximum when the core is continuous), and the greater the leakage of alternating current across the rails, due to the impaired reactance.

The relay can be connected directly to the rails as shown in Fig. 604 without the chance of having excessive amounts of propulsion current flow through it, since in the iron-core reactance bond the voltage drop in one-half of the coils neutralizes that in the other. In the case of traction cross-bonding to adjacent tracks the connection for such cross bonds to the rails may be made only at bond locations and, therefore, the permissible length of such track circuits will be limited by the required frequency of cross-bonding. The size of the bond, for a given reactance, is dependent upon the amount of traction current to be carried and the amount of unbalancing which has to be taken care of.

The track relay P and its operation are the same as described for Fig. 603 and the transformers and the reactance grids are of the same general character. With fair ballasting

Fig. 608. Universal Polyphase Relay. Model 2, Form A (4-way).

conditions, track circuits of this type up to 7,000 ft. in length have been operated successfully. It is possible, however, to operate with equal satisfaction track circuits of twice this length, by placing the energy transformer T′ at the center of

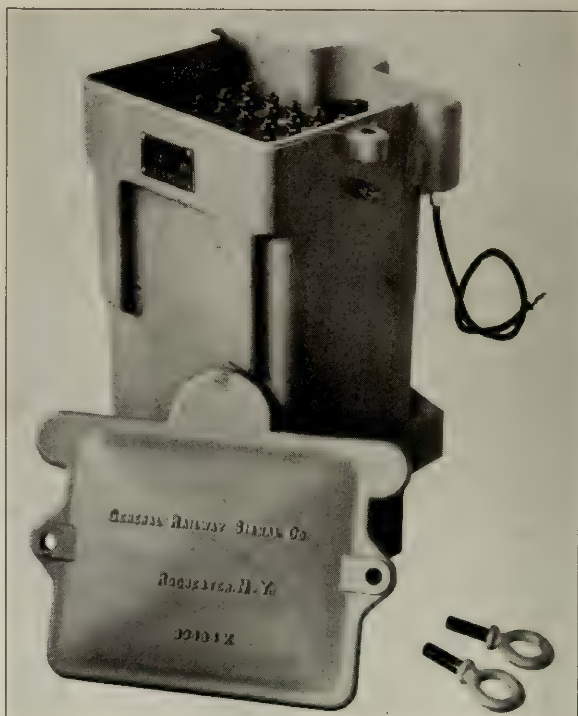


Fig. 609. H3 Transformer.

the section and using the transformer bonds B and the track relays P at both ends, the signal control being carried through the contacts of both these relays in series as shown in Fig. 605.

Aside from the track circuit, above described, the other devices incident to a complete signal system, such as the signals, signal operating batteries, line relays, method of control,

etc., need be no different for electrical roads from those used on steam roads; but since a power line must be strung the entire length of the system to supply the track circuits the signal movements, line relays, lights, etc., can as well be designed to operate from alternating current, thus requiring but one set of generating apparatus and also but one power distribution system.

CUMBERLAND VALLEY INSTALLATION.

The General Railway Signal Company installed, during 1911, 76 Model "2A" signals on a section of the Cumberland Valley Railroad between Harrisburg, Pa., and Mason-Dixon, a distance of about 68 miles. Twenty-five cycle, single phase alternating current is used throughout for the operation of signals and track circuits, and for the lighting of signals, station buildings, etc. The signaled territory includes seven interlocking plants, electrical and mechanical, through which standard track circuit apparatus and signals are used. Fig. 610 illustrates one of the Model "2A" interlocking signals.

Energy for the operation of the signal system is obtained from a commercial power house located at Lemoyne and from the railroad company's plant at Chambersburg. At Lemoyne

Fig. 610. Model "2A" A. C. Interlocking Signal. Cumberland Valley Railroad.

only 60-cycle current was available and, therefore, two frequency changer sets were installed, one of which is held for emergency use. Two 22½-k. v. a. transformers step the current generated by the power station at 370 volts up to the power line voltage of 3,300. The power lines extend in both directions and are so connected through fusible plug cutouts to the power station that either branch may be disconnected.

The railroad company's power station generates 370-volt, 25-cycle, three-phase current, the signal current being taken off one leg of the three-phase circuit to two 50-k. v. a. transformers (one for emergency use.) The power lines are protected in a manner similar to that used at Lemoyne.

At the signal locations type "H" transformers step the current down from the power line voltage to 55 volts, which is used for signal and switch indicator operation, for track relay locals and for the primary of the track transformers. The transformers have a possible variation of 10 per cent to take care of the drop at the points farthest from the power supply. The capacity of the transformers is 400 v. a. Fusible plug cutouts and lightning arresters protect the transformer primary.

The track transformers are of a smaller size than the track relays, which permits their being housed in the relay boxes. They have a capacity of 40 v. a. and give secondary voltages, ranging from 2 to 10 volts. In automatic territory one such transformer is used per track circuit, but through the interlocked sections several track circuits may be fed by one trans-

Fig. 611. Automatic Signal Location. Alternating Current Signals on Cumberland Valley.

former. A 9/10-ohm resistance unit with taps giving variable resistances is placed in series with the transformer leads to the track, to prevent excessive flow of current through the transformer when a train is standing at the location.

The track relays are Model 2, Form A, polyphase. They are of the three-position type, wireless control, operating in one direction to clear the signal to the 45-deg. position and in the reverse direction for the 90-deg. position of the signal; when shunted they stand in the neutral position with their contacts open. The polarity of the track circuit is reversed by a pole changer on the signal in advance reversing the 55-volt primary leads on the track transformer for the section in question. Through interlocking plants, however, the track circuits employ a two-position relay, which is equipped with an indi-

Fig. 612. Automatic Signals, Cable Post, Transmission Line and Relay Box. Cumberland Valley.

cating blade and located in the tower in view of the operator.

The automatic signals are the three-position, upper quadrant Model "2A", with a staggered marker light. The signal is controlled locally through the track relay for the section in advance of the signal. It operates on 55 volts requiring approximately two amperes to clear the blade.

The switch indicators are of standard G. R. S. polyphase construction, operating on 55 volts, the windings being connected in split phase relation so that but one control connection to the indicator is required. The control circuit is broken through the circuit breakers on the proper signals.

The relay boxes are of wood built in one, two and three-way sizes, and clamped to the signal masts as shown in Figs. 610-612. They are equipped with a fuse and terminal board to provide suitable connections for the signal, relay and track transformer circuits.

SIGNALS FOR ELECTRIC RAILWAYS

SYSTEMS

NACHOD SIGNAL SYSTEM.

The Nachod signal system of automatic block signals for electric railways, type CD, is for permissive signaling on single-track lines operating in both directions, with turnouts or sidings at passing points. It gives both facing and rear protection, though without distant signals. The signal indications are controlled not by a continuous track circuit, which may not be easily applied on account of the traction current in the rail, but by the passage of the car or train past a given point at which a contact device is located. This, without moving parts, may be a short section of third rail, an insulated track section, or a trolley contactor.

The system is adapted either for single-end sidings, for through type turnouts, or for curve protection in both directions, the arrangement of the signal apparatus on the right-of-way being shown approximately in Fig. 614 for a through type turnout. There is a distance of from one to two spans between the trolley contactor and the signal aspect, which is in advance. The signal is constructed to indicate affirmatively; that is, every passage of the car under the contactor must make some change on the aspect, visible to the motorman, to prove to him that his car has caused the mechanism to operate.

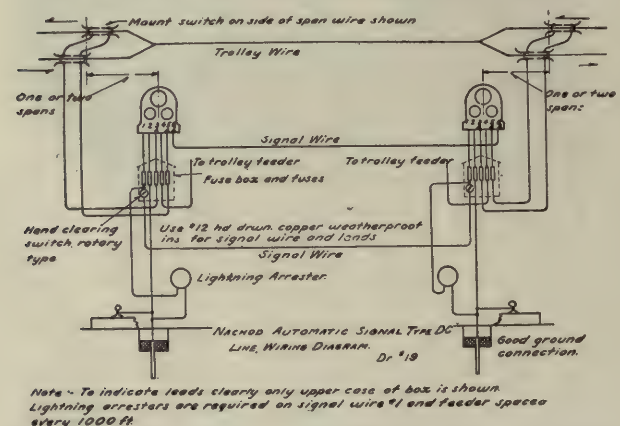


Fig. 614. Wiring Diagram for Through Type Turnout.

The apparatus for one block of single track, as shown in Fig. 614, consists of two signal boxes and four contactors—although two might be used—and two line wires connecting the stations.

The apparatus may be broadly divided into three parts: (1) the signal aspect, consisting of lights and color disks; (2) the intermediate mechanism, or relay, which converts the transient current impulses, caused by the passage of the car under the contactor, into signal indications, and (3) the controlling mechanism, as the trolley contactor.

The aspect is given by lights and color disks simultaneously, the three indications being *no light and no disk; a white light* and a *white disk;* a *red light* and a *red disk.*

The signal box forming the aspect is a substantial weatherproof cast-iron case of compact and pleasing contour. The lower part is an oil tank which may be removed by three bolts so as to expose the relay. The upper part is attached to the pole by hangers, and contains the lights and disks, which are actuated by means of the relay magnets. The magnet connection is through a push rod so that there is no shock transmitted to the disk by the quick motion of the magnet plunger. These disks are of enameled aluminum, counterweighted to fall to indication by gravity. Only one lamp is lighted at a time, at which time the disk of the same color rises to an indicating position, and is viewed through the clear glass roundel in the hinged front of the box. Below this there are openings for a white and a red semaphore lens for the lamps. It will be seen that the disk not indicating acts to screen from cross illumination the lens not indicating.

The relay is attached to the upper case by three bolts which, when removed, allow it to drop away, disconnecting automatically both the electrical contracts and the push rods from the color disks. This unit, shown in Fig. 618, consists of five magnets, the upper pair of which counts the cars by a ratchet and pawl mechanism; each entering car operating the left-hand magnet A (Fig. 617), to revolve the ratchet wheel and its attached revolving switch one notch in the counter-clockwise direction, and each leaving car actuating the right-hand magnet D to move the ratchet wheel one notch in the opposite direction. Thus, if the signals are neutral or normal, with no cars in the block, with the revolving switch in a certain position, they will be restored to neutral when the same number of cars have left the block as have entered. The latter magnet also operates the white color disk, and the left lower magnet H, the red color disk. The right-hand one, C, is the clearing magnet. Behind this magnet, visible in this view, is the no-voltage magnet N to prevent change of signals on failure of line voltage. To the left, in Fig. 618, will be seen the resistance rods vertically mounted with contact bands for adjustable taps. The entire unit depends from a contact board having terminal studs which impinge upon phosphor bronze spring contact strips in the upper case. By this means a relay may be removed by taking out three bolts, and a spare one substituted without touching the wiring in any manner.

Some unusual features of this relay, which is in fact the heart of the signal system, are, in the first place, the use of partially iron-clad substantial plunger-type magnets instead of the delicate pivoted armature type, reducing wear and the possibility of sticking, since the power for operation is not

Fig. 615. Signal Box, Showing Method of Suspension.

minute, but may be as great as desired. Contacts are made and broken by the simple rectilinear movement of the plungers, without pivots or multiplying levers, there being phosphor bronze spring fingers pressing against brass rings separated by insulating material. The alignment of parts is through finished metal surfaces. The most novel feature of the design, however, is the immersion of the entire relay in a tank of transformer oil. By this means not only is continuous lubrication provided and corrosion prevented, but the relay is sealed against the entrance of foreign matter, dust, insects, etc. Moreover, the oil acts to cushion the variable magnet blows which might tend otherwise to loosen the screws. Furthermore, the high insulating power of the oil greatly reduces damage by lightning, which has always been a serious menace in connection with such signals, and it also permits parts of opposite polarity to be brought closer together than in air, thereby resulting in a more compact design. By the cooling properties of the oil, which transmits the local heat from the coil to the entire tank for radiation, the range of the voltage operation is increased, since enough current for positive operation may be used for abnormally low voltages, and yet the coil will not be overheated with the normally high voltage. The life of the contact fingers is enormously increased by the quenching of the arc under oil, so that altogether the very great advantages due to oil cooling and oil insulating, so long used in transformers, together with that of the oil-break switches, are obtained.

Instances are on record where signals with such relays have operated for a year at a time with no attention whatever.

The trolley contactor shown in Fig. 616 consists of two, flexible longitudinal steel contact strips, supported by a rigid member near the trolley wire, but insulated from the latter, so that the wheel running on the wire,—which it does not leave,—touches in passing one or both of the contact strips, which are electrically connected. These strips are inclined outwardly at the bottom, flared at the ends to receive the wheel easily, and mounted by flexible phosphor bronze suspenders. The deflection of the strips, however, is positively limited by steel brackets shown. Each strip is divided into halves electrically and reunited through insulation so as to obtain a sense

of direction without the use of moving parts. The insulation between the contact strips and trolley wire is through hickory, impregnated under vacuum and pressure with a weather-proofing compound. The entire contactor, which is about four feet long and weighs 18 pounds, is hung by a double-curve suspension at one end, and clamped to the wire by the usual trolley ears. This contactor receives the various size wheels without shock, and operates the signals very successfully at car speeds of 55 miles an hour. The position of the car controller handle does not in any way affect its action.

The neutral signal, *no light* and *no disk*, presumes that the block is clear, and gives the first car the right-of-way to run under the contactor, but no further.

The change from neutral to proceed, a *white light* and a *white disk*, gives the first car the right-of-way to continue through the block; but a neutral signal is to be taken as a stop signal should the neutral remain after the car has

If a motorman should enter a block, setting the signals, and remain there, then cars for any reason entering and backing from either end in any manner, whether against the red or white signals, will not disturb the signals as set by the first car; and only when all the cars have vacated the block will the signal be restored to neutral.

The trolley contactors have a sense of direction so as to count cars into or out of the block, according to the end of the contactor first reached by the trolley wheel. The operation is perfectly general and cars may enter and leave by any one or by all the contactors.

If two cars from opposite ends enter at exactly the same instant, the white disks will not remain set, but will disappear immediately, leaving neutral signals when the car leaves the contactor, and before it passes the box. Each car should back out of the block, and the one having the superior right should go forward, setting the signals against the other car.

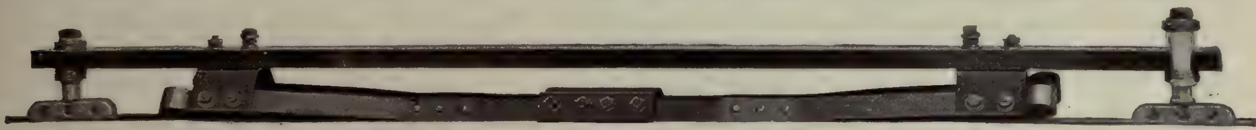


Fig. 616. Trolley Contact for Nachod Signal System.

passed the contactor. It indicates that the stop signal has not been set at the far end of the block.

The proceed signal notifies the second and following cars that the block is occupied by cars running in the same direction; and the "blinking" of the light, as the second and following cars run under the contactor, gives them the right-of-way to continue through the block.

The stop signal, a *red light* and a *red disk*, warns the motorman to stop and remain behind the contactor so long as it is exhibited.

The motorman must not pass the signal box to enter the block unless the white light and white disk are showing.

A car must not follow into a block already occupied unless the motorman sees the white light blink as he runs under the trolley contactor.

Motorman must not allow car to remain standing with the trolley on the overhead contactor.

Fig. 617 shows the operation of the electrical system, the apparatus being alike at both stations, and in the normal position with no car in the block.

The directional trolley contactor 3A, 5A, is divided into halves, reached in succession by the trolley wheel. These are interconnected by means of the directional magnets E and F, so that a car entering from the end 3A will close the signal-setting circuit through coil A in the relay, and hold it closed even after it reaches the second strip 5A. But should a car reach the end 5A first, then the circuit will be closed through the clearing magnet C in the relay, and held closed by the directional magnets even after it reaches the second strip 3A.

The circuits through the directional relay are described herewith once for all, and not each time they are mentioned. A car reaching the trolley contactor from the end 3A diverts a current from the trolley wire 4 through 3A, 3, coil E, 19,

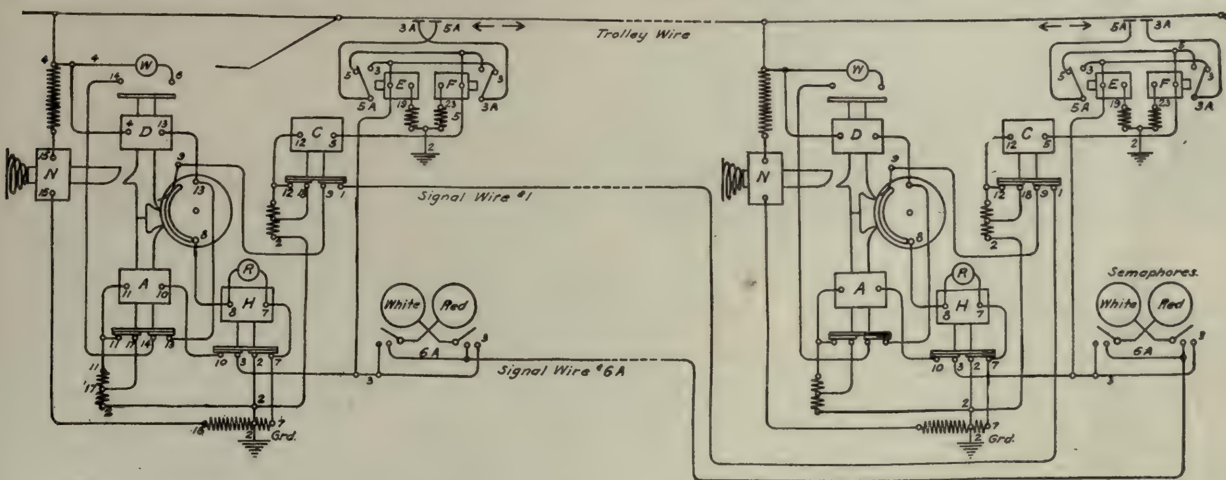


Fig. 617. Diagram of Operation, Nachod Signal, Type "D."

The first car to enter the block in passing under the contactor sets a white light and a white disk, which is an indication that the red light and red disk are showing at the far end. Every successive car following in an occupied block indicates that it is registered by extinguishing the white light as it passes under the contactor, the light reappearing the next instant.

Fifteen cars may enter the block in succession and occupy it at once, or they may be continually entering and leaving, and they will all be protected.

If the motorman should accidentally overrun the entering contactor when the signal shows red he will not visibly affect the signals, but will count in the car on the relay; and this change will be canceled when he backs out of the block again under either contactor to wait.

If the motorman should enter a clear block, under either contactor, setting the signals, and back out on either track at the same end of the block, as he might in using the single track at a Y or cross-over, the signals will be automatically cleared on leaving.

to ground 2. Coil E attracts its armature, breaking the contact at 5 and making that at 3, so that when the car reaches the second part 5A, the circuit still includes coil E, being made from 4, 5A, 3, coil E, 19, 2, ground. The setting magnet A is in multiple with coil E, and is, therefore, energized with it. In an exactly similar manner, if 5A is reached first, then the circuit is through magnet F, which will attract its armature and maintain current in it even when the car has reached 3A. The clearing magnet C in the main relay, being in multiple with magnet F, is therefore continuously energized while the car is on the contactor, having approached it from the end 5A. The divided contact strips and the directional relay magnets E and F thus act selectively, to actuate coils A or C according to the direction of the car.

In the clear block, both ends of the signal wire are grounded through the circuit, 1, 9, 8, 7, 2, ground, including coil H and the red lamp.

A car entering from the left temporarily connects contact strip 3A of trolley contactor with trolley wire, forming a circuit, 4, 3A, 3, 10, 11, 17, 2, ground, passing through

coil A. This impulse of current in A moves its plunger to revolve the two-way switch, transferring the end of the signal wire 9 from contact 8 to contact 13. Current then flows from trolley wire, 4, 13, 9, 1, signal wire to other relay to ground as described. When the car leaves the contactor, plunger A drops back into the position shown, while plunger D remains in the retracted position on account of the current in coil D. The white light now burns, since it is in shunt across D by the path 4, W, 6, 14, 13; and the red light also burns in the other relay because of the current in the signal wire. The retracted position of plunger D in the one relay, and that of plunger H in the other, permit the display of the white and red disks, respectively. So long as the red signal continues, the circuit of magnet A is held open at 3, 10, preventing change in the left relay by cars entering at contactor 3A against the red signal. The effect of successive entering cars is to revolve the switch so that the contacts overlap further, but not to cause any electrical change in the signal circuit, except that each entering car actuates magnet A so as to break the lamp circuit at switch 13, 14, causing the white light to blink.

When the car leaves the block at the right end it runs under contactor 5A, completing the circuit, 4, 5A, 5, 12, 18, 2, ground. The plunger of magnet C opens the signal line wire circuit at 1, 9, breaking the circuit of magnet D in the entering relay. The plunger of D is restored to its original position, revolving the switch in the reverse direction, one notch at a time for each leaving car. When there have been as many breaks of current in coil D as impulses of current in A, the

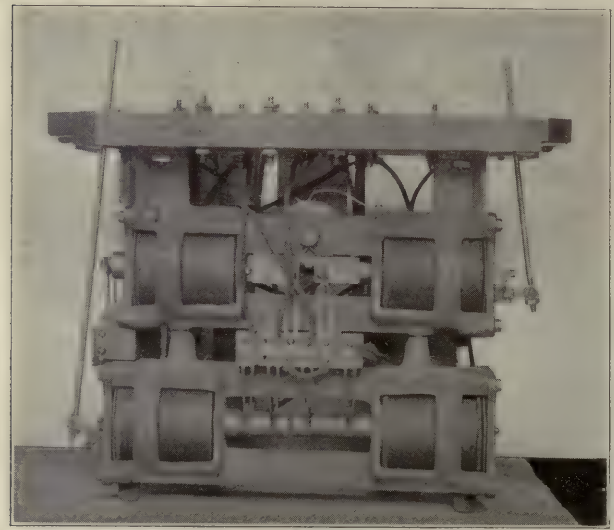


Fig. 618. Nachod Signal Relay Unit.

revolving switch will be in its original position, and the signals will be cleared.

If the car enters the block by contactor 3A, 5A, it will energize magnet A and set the signals; while if it backs out under the same contactor, it will energize magnet C to clear them. If a car should accidentally overrun the contactor against a red signal, then current would flow through signal wire 6A to the distant relay, and through setting coil A there, by means of the color disk switches, one of which will be closed in each signal box. But there would be no effect on the signal showing red, since the circuit of the setting magnet A would be held open at contacts 10, 3, as stated. The second signal wire 6A is, therefore, a means for enabling a car running against the red signal to count in on the distant relay, that it may count out again in backing. It is in use only in such rare instances.

The function of magnet N is to prevent change of signals should the power fail with cars on the block. It is permanently connected across the line in series with a high resistance, 4, 15, 16, 2. Should the current fail while the plunger of D is drawn up, the plunger of N will catch that of D to prevent it from rotating the ratchet.

All the magnets are arranged so that after the stroke is partly completed, the current in the coil is reduced either by insertion of resistance or by shunting current around them. For instance, before the plunger of C moves, the current passes through the resistance 18, 2 only, but after it has moved it passes through the additional length 12-18 and is, therefore, reduced in strength. By this means the magnet is operative over a very large voltage range; and is also protected from burn-out should the car remain under the trolley contactor. Magnet C is provided with a dashpot to retard its return motion and allow magnet D to act during the breaking of its circuit.

THE UNITED STATES ELECTRIC BLOCK SIGNAL SYSTEM.

In the signaling system made by the United States Electric Signal Co. the apparatus contained in a block of signals consists of two signal boxes, four disk attachments and four operating trolley switches. The boxes contain, for the home signals, both lights and disks, the light being placed in the disk case and being visible through the glass enclosing the same, therefore making a complete and independent visual signal in itself as well as to illuminate the disks in the night-time, as shown in Fig. 623.

Two sets of home signals are used at each station; one on each side of the main box, and alternate successively for each car as it enters the block. That is, a car upon entering the block will display one set of the home signals (both light and disk) either on the right or left. Upon the second car entering, another set (both light and disk) will be displayed on the opposite side of the box and the ones that were formerly displayed will be restored.

At the distant end of the block a red light only is used for a danger signal. A car upon leaving the block at the distant signal will maintain the red signal set and momentarily display one of the home signals at that end. During this operation the home signal at the entrance end of the block will also be momentarily restored and the red signal will be momentarily displayed.

Four operating trolley switches are used and are located over the double track some distance from the junction, so that a car will be able to come to a stop before reaching said junction if it should be blocked by the red signal upon entering the block. The setting switches are provided with setting connections only. Therefore, if a car should unavoidably pass the same after the signal had been set from the distant end of the block, it can move back and get into position to proceed and set the signal after awaiting the passing of the coming car without danger of turning off or restoring the set signal in so doing. The restoring switches are placed on the opposite track and are provided with restoring connections only and are only operative by cars leaving the block.

The signal relay consists of a step wheel, locking devices and four operating magnets and switches governed by their armature, the two forward magnets operating to set and restore the signal,—the one on the right to set, and the one on the left to restore.

The front and right-hand magnet is charged from the overhead trolley switch directly to ground through a resistance of its own as the car enters the block, which serves to turn the step wheel one step in the accumulative or setting direction. This operation causes the switch lever to move from the ground contacts on the right to the feed contacts on the left.

The distant end of the circuit being in connection with the ground by means of the springs on the right at that end, a circuit is thus established and the signals are electrically displayed. When the signals are thus displayed one set of the home signals on the side of the home box is displayed.

The second car upon entering the block and during the time the first car is yet on the block will display the set of signals on the opposite side of the box and restore the set that were formerly displayed and thus alternate as heretofore mentioned.

At the distant end, the red light in the upper part of box proper will remain constantly displayed during the operations. When the signals are thus set the current will flow through the home box through the home signals and the rear left-hand magnet of the relay at said home box.

This latter magnet at the home box operates the lever which serves to lock the restoring armature lever by co-operating with a pin extending through the same so that the restoring magnet cannot operate to restore the signals until the signaling circuit is opened. This circuit can only be opened at the trolley switch and by a car passing off of the block. Therefore, if the line should become charged by the crossing of the wires between stations, the signals could not be restored on account of this lock.

At the distant signal box the signaling current will flow through the red lamp and the restoring magnet.

The pawl or operating lever carried by the armature of this restoring magnet serves as a locking device to prevent the step wheel being turned if a car should by accident run past the setting switch, going on to the block after the signals had been set.

By a peculiar arrangement of co-operating pins in the periphery of the step wheel and the side of the restoring pawl, the pawl is held into engagement with the step wheel after the signal has been fully restored, thus maintaining its restored

position and at the same time mechanically holding the armature up to the poles of the restoring magnet.

The signals are restored by a car leaving the block by means of the overhead trolley switch, located as heretofore described, from which the current will flow to the rear right-hand magnet of the distant box of the danger or red set signal, thence into the unlocking circuit and to the home box which has previously been set by cars entering the block, thence through the restoring magnet and through the red signals to ground,

step wheel being mounted loosely on the same, so that it will revolve without rotating the shaft and operating the alternating lever when being rotated in the direction of restoration by a car leaving the block.

However, by means of a ratchet wheel, which is mounted rigidly to the shaft with a pawl securely attached to the step wheel adapted to engage the ratchet wheel, the shaft and the notch wheel that serves to alternate the signals will rotate when operated by a car entering the block.

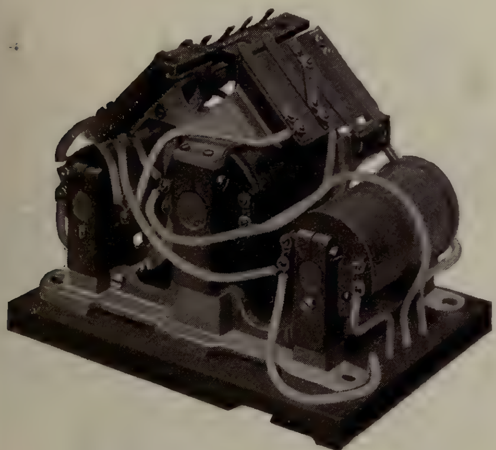


Fig. 610. Signal Relay Type G1.

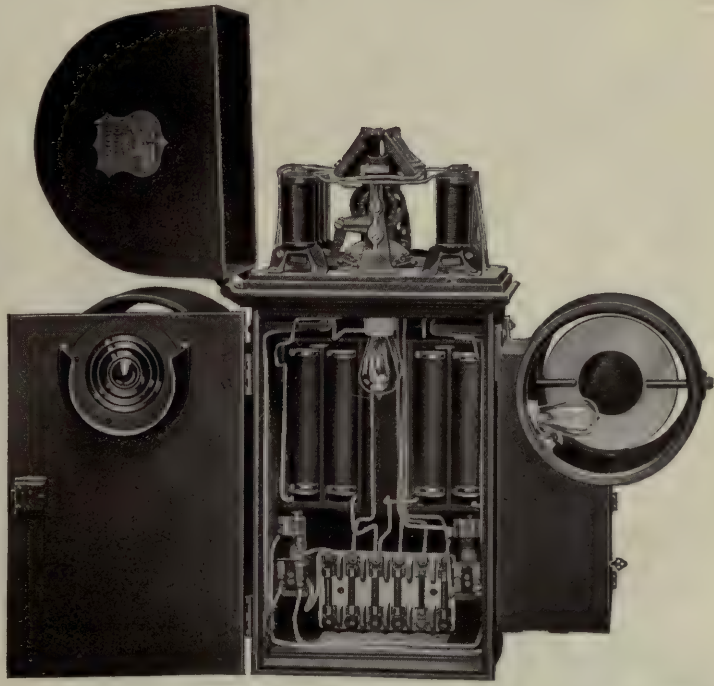


Fig. 620. Type K Signal Mechanism. Open. United States Electric Signal Company.

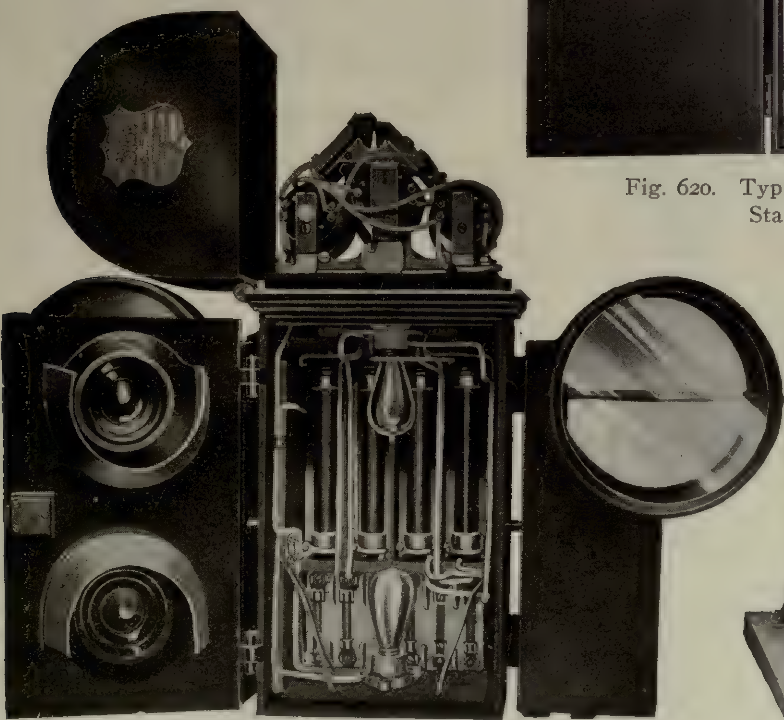


Fig. 621. Type G1 Signal Mechanism. Open.

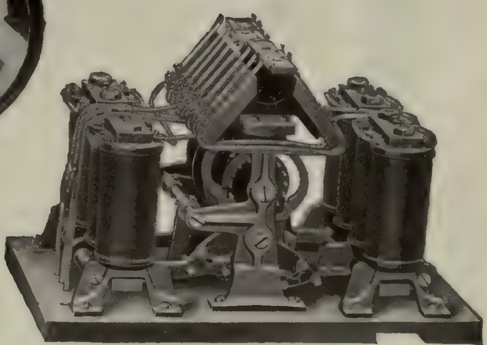


Fig. 622. Signal Relay. Type K.

thereby charging the first magnet mentioned at the distant or red set signal.

This will cause the contact lever carried by its armature to move over from right to left, opening the main signaling circuit at the spring contacts on the right at the distant box.

The locking magnet on the rear left of the home box will then be discharged, allowing the locking devices at the home box to operate to unlock the restoring magnet at the home box and cause it to operate to rotate the wheel back toward the point of restoration one tooth, as represented by the out-bound car.

The circuit opening magnet at the distant box will again close the signaling circuit, and if there are yet cars in the block, charge the left-hand rear magnet at the home box, thereby again locking the armature of the restoring magnet at the home box.

The alternating lever is operated by means of a notch wheel, which is mounted rigidly on the shaft of the step wheel, the

The main switch lever that serves to set and restore the signals to normal is operated by a cam wheel rigidly mounted directly to the step wheel.

With this understanding, it will be seen that the main switch lever does not operate except for the initial setting of the signals by the first car and the final restoration of the same by the last car.

This device just explained prevents the signals alternating when the step wheel is rotated in the direction of restoration by a car leaving the block, thereby anticipating any possible danger of confliction of display by cars entering and leaving the block at the same time.

Fig. 624 shows the standard signal box equipped with disks in addition to the colored lights. These disks operate independently of the lights and are located on opposite sides of the box. The lamps operate in unison with the disks.

Figs. 619 and 622 show the relay. It is the mechanism which, in conjunction with a trolley switch, operates the lights and

disks. There is a small mechanical lock in the mechanism which holds the lever in a closed position until it is unlocked by a car leaving the block. The disks which furnish the indications in addition to the lights are housed in separate castings, which are fastened to the main signal box. The disks are eight inches in diameter and are pivoted horizontally between two glass windows. They are made of sheet metal, painted and varnished. One disk is red and the other is green and white. The disks are operated by a large magnet placed in the lower part of a housing and there is no connection between them and the main signal box. They work independently of the lights. Lenses five inches in diameter are used in the lights.

The actual location of the wires, contacts and fuses connected with the United States system is shown in Fig. 626 and the path of the current through the magnets and signals and the manner in which the signal is set and released are indicated. With the signal in its normal position the mechanism is in the position shown in the figure and there is no current flowing through the system. When the car represented by the wheel entered the block it closed the right-hand contacts of trolley switch for an instant, allowing the current to flow over the circuit represented by heavy dashes, through magnet A and over line wire No. 3, through the other signal, to the ground, as shown by the heavy full line.

Magnet A, upon being energized, throws over its contact lever, disconnecting the ground at this, the setting end, and cutting in a permanent feed from the trolley wire to take the place of the switch contact, which opens immediately after the car passes. This permanent feed also throws the green lamp and disk into the signaling circuit and it is their appearance which tells that the red signal is displayed at the opposite end. The other set of contacts closed by this magnet completes a circuit which starts in the outside contacts of both trolley switches. It will be seen, upon looking at the diagram, that the signaling circuit leads through magnet B′ at the other end, opening a pair of contacts known as the non-interference device. These contacts open the setting circuit from the trolley switch and prevent a car trying to enter from the opposite end, locking up the lever to magnet A′, which would connect both ends of the signaling circuit to the trolley wire, making a dead signal until some car passed out of the block. The circuit indicated by light dashes is known as the releasing circuit. When the car leaves the block, going in the direction shown by the wheel, it closes the right-hand contacts in the right-hand switch, thus allowing current to flow through magnet C′, which breaks the main signaling circuit, and also through magnet B, which unlocks the lever of magnet A. The magnet A, now being de-energized and the lock open, allows the lever to fall back and the system is in its normal position of no car in the block.

In proceeding with this illustration it will be necessary to understand, in a general way, the mechanical operation of this character of signal. This signal provides for a multiplicity of cars in a block at a time by means of a step wheel, which is rotated in one direction by cars entering the block, and in the opposite direction by cars leaving the block. This is accomplished by means of magnets having armatures carrying pawls that engage the teeth or pins in the rim of the step wheel. The magnet (with its pawl) on the right-hand side is the one that operates to turn the wheel in the setting direction, and the one on the left is the one that turns it in the direction to restore. It will be understood that the step wheel will be turned one pin for each car as it enters the block, and it will be turned back in the opposite direction one pin for each car as it leaves the block; and when as many cars have passed off the block as have passed on to it, the wheel will be brought to a normal position and the signal will be restored to normal.

Fig. 624. Type G_1 Signal Box.

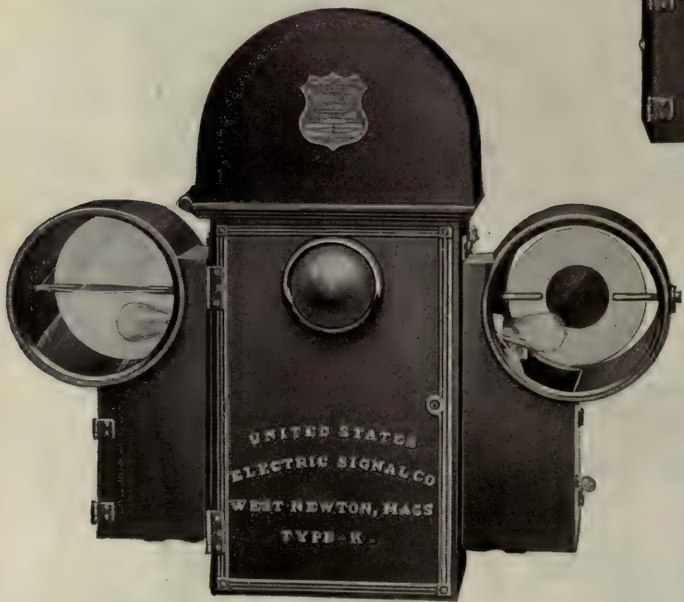


Fig 623. Type K Signal Box.

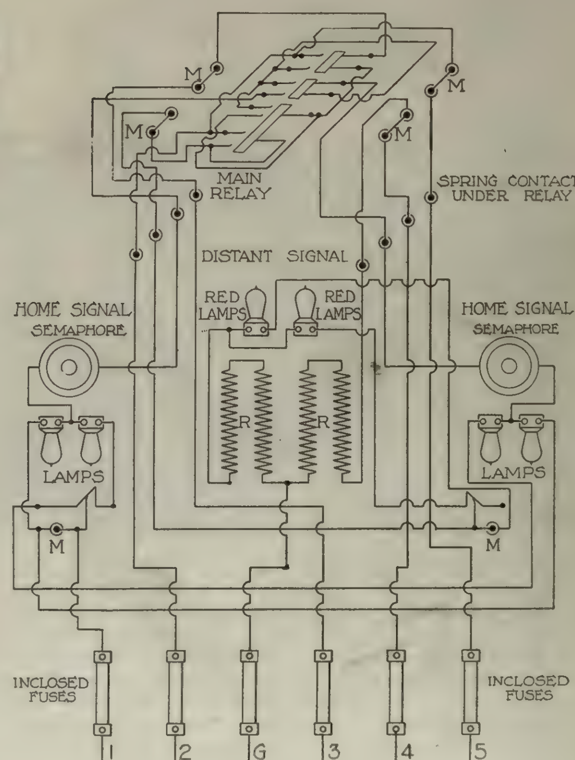


Fig. 625. Wiring Diagram for Type K Mechanism.

In Fig. 626, when the trolley wheel passes the switch going on to the block, it closes the circuit at the point marked "trolley switch." The current will flow through the heavy dotted line to the No. 4 terminal in the box, through the fuse and the front right-hand magnet to the resistance, into the ground wire and to the ground. This will cause the setting magnet to be energized and will operate to turn the step wheel one pin in the setting direction. This will cause the main contact lever, which is the front one, to move over from its normal position on the right to the contact spring on the left. The current will then flow from the trolley wire, over the heavy full line to the No. 1 terminal through the fuse, thence to the pick-up magnet to the lamp on the right-hand side of the box, thence to the semaphore to the spring contacts on the right, crossing over to the spring contacts on the left back to spring contacts on the rear right; thence to the locking magnet leaving the home box at the No. 3 terminal, and through

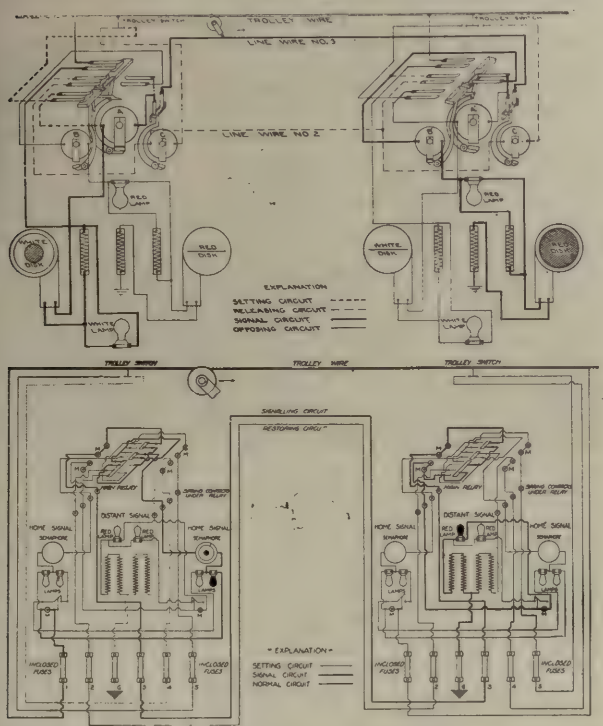


Fig. 626. United States Block Signal System. Circuits with Car in Block.

the wire of the signaling circuit to the No. 3 terminal at the distant box; thence to the rear left-hand magnet to spring contacts on the rear right to spring contacts on the front right; thence to the restoring magnet on the left to the pick-up magnet on the right, and to red lamp at the top of the box, through the resistance to ground. As indicated, this will cause the top lamp in the right-hand disk box and the disk also to be displayed at the home box, and the front lamp in the upper window of the distant box to be displayed. Upon a second car entering the block, the alternating switch, which is the middle one of the relay, will move over to the opposite side of the box, opening the springs on the right and closing those on the left. This will cause the current to flow through the lamp and disk on the left-hand side of the box, thus displaying another set of signals at the home box. These signals will alternate successively as cars enter the block for as many as 15 cars, the distant red signal remaining constantly displayed during these operations.

When a car leaves the block, the contacts will be closed at the restoring side of the trolley switch, and the current will flow over the wire, represented by the light full line, leading to the No. 5 terminal at the extreme right of the box, to the magnet at the rear right-hand side of relay into the No. 2 circuit. The current will then flow over the restoring circuit to the home box, which has been set by the cars entering the block, will enter the same at No. 2 terminal through the fuse to the front contact lever, and through it to the front left-hand magnet, thence to ground through the red signal, momentarily energizing the front left-hand restoring magnet at the home box and the rear right-hand magnet at the distant box. This will cause the contact lever at the rear of relay to move over to the left and open the signaling circuit, at the same time closing, by means of the contact springs, a derived circuit to prolong the charged moment of the restoring magnet.

KINSMAN BLOCK SYSTEM.

A system of automatic block signaling for electric railways operated by direct current and controlled by track circuits has been designed and installed by the Kinsman Block System Co. The indications are given by semaphore and light signals. The track circuits consist of two insulated rail sections at each end of the block, a relayed rail being used as a jumper around the insulated section, for the return traction current. There are two track relays, one called the setting and the other the releasing relay operated by two cells of primary battery. The controller is a step-by-step mechanism designed to allow cars running in the same direction to enter a block. Each car entering the block sets the controller one step forward, and each car leaving the block sets it one step backward until the last car leaves, which restores the controller to normal.

Cars going in the same direction may thus be continually entering and leaving the block under signal protection. Fig. 627 is the front view of the controller with the cam in the normal or clear position. This shows the switch, which governs the signal movements in the normal position. When the front ratchet, which is controlled by the setting magnet, is operated, this cam turns clockwise, and as it does so it forces the pin, shown on the switch, down, so that the switch is thrown. A second, third, or fourth operation of the setting ratchets would operate this cam in a clockwise direction, but would not affect the switch. The cam simply revolves the angular distance of one tooth as each car enters the block, thus actually counting, or recording, the number of cars. As each car passes out

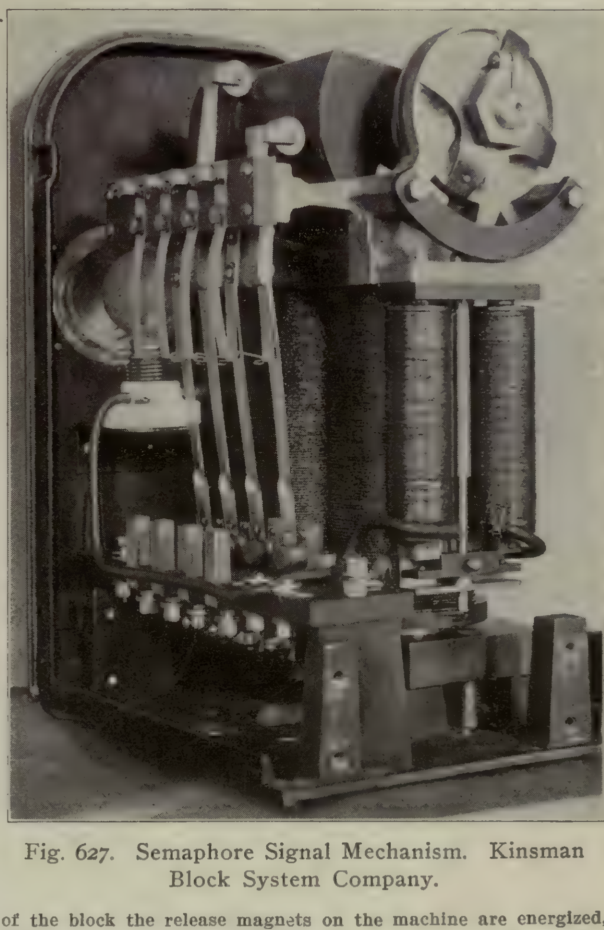


Fig. 627. Semaphore Signal Mechanism. Kinsman Block System Company.

of the block the release magnets on the machine are energized, the release ratchet wheel is operated, and the cam is operated counter clockwise, moving it back towards its normal position. There is no movement of the switch until the last car passes out of the block when the cam operates the switch. When the last movement of the cam is made, the pin on the switch is forced up into the slot in the cam. This rocking move of the switch is called a "Geneva" movement. There is a brass rod on each side of the machine upon which are wound steel springs. Each of these springs forces down one end of the lever. The other end of this lever is lifted up and engages the lower arm of the pawl, which is connected to the armature of the magnet. This lever, by virtue of the spring tension, lifts up the pawl when the magnet is released, and also lifts up the armature of the magnet. As the pawl is lifted up it is also forced against the ratchet wheel, so the pawl drops into the

notch of the ratchet wheel. There is a small dog at the top of the controller which is used as a detent. This detent simply prevents the ratchet wheel from turning in the opposite direction when the operating pawl is being lifted up after it has completed a stroke. When a car passes over the releasing section, the releasing magnet becomes energized and the release ratchet operates, revolving in the opposite direction. This will screw. This cam operates the electric switch. The shaft also has the casting, which carries the aluminum beveled gear. This casting is keyed to the shaft. There are also on the shaft the armatures of the two pairs of magnets; these operate loosely on the shaft, and are not rigidly connected with it. There are also the two main ratchet wheels, which likewise operate loosely on the shaft. The two brass beveled gears are riveted and

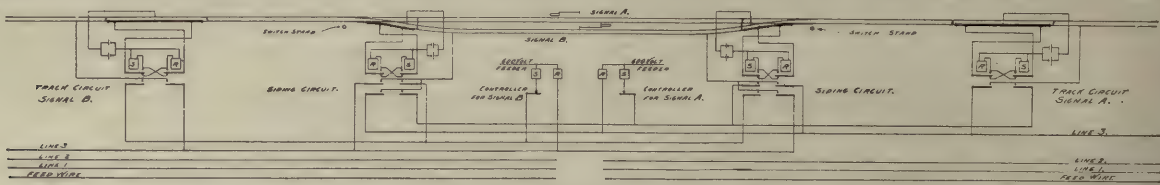


Fig. 628. Arrangement of Signals and Insulated Sections at Double End Sidings. Kinsman Block System Co.

set the swinging contacts at normal. If more than one car passes through the block in the same direction, each car, as it passes over the setting section, will cause the setting ratchet to operate and move the cam one step, and as each car passes over the releasing section at the far end of the block, it will cause the cam to move back one step toward putting the swinging contact again to normal. For example, if five cars were moving in the same direction through a block, the whole five cars would have to pass through the block before the signals would clear up, and should any of these cars have occasion to

Fig. 629. Semaphore Signal. Kinsman Block System Company.

back up and leave the block at the end they entered, the signal would clear up just as if they had all gone through the block. Two resistance tubes, placed between magnets, are wound with fine wire and inserted in place the same as a fuse is mounted between metal clips. These resistances are connected to the 550-volt circuit on one end; the other end of the front resistance is connected to the setting magnets, which are in series. The other end of the resistance in the back is connected to the

soldered to the ratchet wheels, and they also are loose on the shaft. The armatures have a fixed stud in their upper ends, which carries the pawls that operate the ratchets. The pawls are free to turn on this stud. When the right-hand ratchet wheel is operated by the pawl attached to the right-hand magnet (this is the setting magnet) it is turned in the right-hand, or clockwise, direction (when viewing the machine from the end which has the cam), the release ratchet wheel is operated in the opposite direction, so that if both of these wheels were to operate at the same time the aluminum gear would simply be revolved on its axis without causing any movement of the shaft; but should the setting magnet operate, while the release magnet is not affected, the ratchet wheel, by means of the gear wheels, would turn the shaft and cam in a clockwise direction. When this movement is made the aluminum gear is turned by the setting side of the machine (the release side being stationary). It is clear that the only motion transmitted to the shaft is the difference of the motion of both setting and release ratchet wheels. The only time that both these wheels would be operated at the same instant is when the car is entering the block at the same time that a car is passing out of the block at the opposite end.

In Fig. 631 the semaphore blade and spectacle are controlled by two magnets, "A" and "B." Magnet "A" is the operating magnet, which, when energized, operates the signal to the "clear" position and holds it in that position normally. When magnet "A" is de-energized the signal operates by gravity to the "stop" position unless the slot magnet "B" is energized, in which case the semaphore is stopped and held in the 45 deg. position. There are two pairs of contacts, "E" and "G," which are closed when the signal is in the vertical or 45 deg. position. These contacts are opened when the signal is in the horizontal or "stop" position.

The signal mechanism, as described, is operated by circuits which are made up through the controller. The controller is operated by two magnets, "S" and "R." Magnet "S" is energized each time a car passes over the insulated sections of track while entering the block. Magnet "R" is operated each time a car passes over the insulated sections while leaving the block. The controller is operated by a track circuit which consists of two relays, "S" and "R," which are operated by current from two cells of battery. These relays are connected to short adjacent sections of track, "S" and "R." When a car approaches the signal while entering the block it runs on the track section "S," which completes a circuit operating the setting relay "S." The operation of this relay opens a circuit to the release relay "R" and connects the insulated sections "S" and "R" so that the setting relay remains energized until the last wheels of the car or train have passed off the section "R." As a car passes

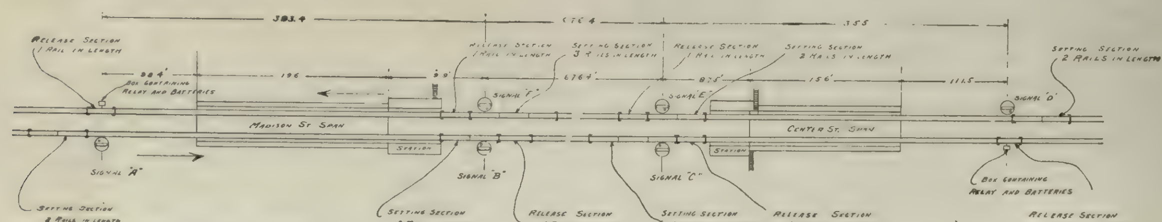


Fig. 630. Arrangement of Signals and Insulated Sections on Double Track.

release magnets, which are also in series. The other terminal of the setting magnet is carried to the front contacts of the setting relay, whereas the extra terminal of the release magnet is carried to the front contacts of the release relay. There is a shaft that extends through the machine, and on the right-hand end there is a cam securely fastened to it with a set

over the insulated sections when leaving the block the release relay is energized. This opens the circuit of the setting relay and connects the sections "S" and "R" so that the release relay remains energized until the car has passed over both sections. The operation of the setting relay operates the setting magnet on the controller, which causes the controller shaft and cam to

operate one step in a clockwise direction from its normal position and each operation of the release relay operates the release magnet on the controller, operating the shaft and cam one step toward the normal position.

The first operation of the setting magnet turns the shaft and cam one step and the switch of the controller is thrown to the reverse position from that shown on the drawing. Each succeeding operation of the setting magnet causes the shaft and cam to turn one step, but does not affect the switch. Each operation of the release magnet on the controller causes the shaft and cam to operate one step toward the normal position, but does not affect the switch until the last step is made when the cam assumes its normal position and throws the switch to normal, as shown on the drawing. Whenever the setting magnet of the controller is energized the contacts "F" are closed. Whenever the release magnet of the controller is energized the contacts "H" are closed. There are two line relays "L," one in each signal and these relays are normally energized.

There are three circuits through magnet "A": First—This magnet is normally energized and holds the signal in the "clear" position by current which flows from the feed wire at station "A," through magnet "A," through the front contacts

Current flows from the feed wire, through a resistance, through the controller switch and contacts "RR" and through the slot magnet "B" to ground. This causes the slot magnet to operate so that the signal is stopped in its downward movement and held in the 45 deg. position. This operation of the signal from "clear" to "caution" is authority for the car to proceed through the block.

As each succeeding car enters the block it operates the setting relay and the setting magnet on the controller and closes contact "F." The closing of contact "F" completes the third circuit just described above through magnet "A" and causes the signal to operate from the "caution" to the "clear" position as the car runs on the insulated sections. As the car runs off the sections the contact "F" opens and allows the signal to operate by gravity from the "clear" back to the "caution" position. This operation of the signal from "caution" to "clear" and back to "caution" again is the authority for each succeeding car to proceed through the block.

There are three circuits through the line relays "L": First—Current flows from the feed wire at station "A" through a resistance, through the controller switch, through contact "RN" on the controller, through contact "E" in the signal,

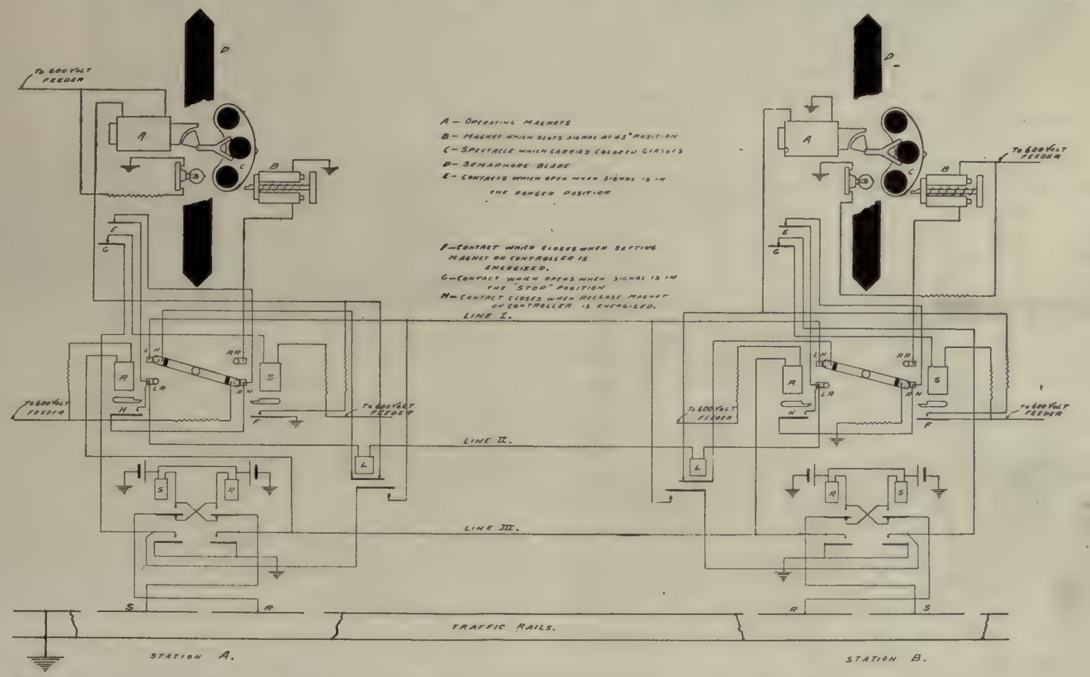


Fig. 631. Controlling Circuit for Kinsman Block System on Single Track Electric Railways.

of the line relay "L" at station "A," through the controller switch, through contact "LN" at station "A," over line wire 1, through contact "LN" on the controller at station "B," through the controller switch, through the front contact of the line relay "L," through magnet "A" to ground. As a car enters the block at station "A" the controller in that signal operates and the switch is thrown to the reverse position. The circuit just described is opened at the switch contact "LN," de-energizing the magnet "A" in signal "B" and allowing that signal to operate by gravity to the "stop" position. Second—The operation of the controller switch to the reverse position completed a circuit through magnet "A," as follows: Current flows from the feed wire connection at station "A," through magnet "A," through the front contact of the line relay "L," through the controller switch, contact "LR," through the winding of the line relay "L" at station "A," over line wire 2, through the winding of the line relay at station "B," through contact "LR" of the controller, through contacts "E" in the signal, through contacts "RN" in the controller and through a resistance to ground. This circuit causes the signal "A" to remain in the "clear" position unless the signal at station "B" assumes the "stop" position, when the contacts "E" in that signal are opened. Third—Current flows from the feed wire at station "A," through magnet "A," through a resistance and through contacts "F" to ground.

After the controller switch is operated at station "A," the signal at station "B" assumes the "stop" position and opens contacts "E" in that signal, and as the car which is entering the block passes off the insulated sections the contacts "F" are opened and then magnet "A" is de-energized so the signal operates away from the "clear" position. The operation as the controller switch completes a circuit is as follows:

through contact "LR" on the controller, through the line relay "L" at station "A," over line wire 2, through the line relay at station "B," through the contact "LR" on the controller, through the contact "E," through contact "RN" on the controller, through the controller switch and through a resistance to ground. Second—When the controller switch was operated as described the second circuit was completed through the magnet "A" at station "A," through the line relays and contact "E" in signal "B." This circuit kept the signal "A" and the line relays energized unless signal "B" assumed the "stop" poistion. The line relays were de-energized as soon as the contacts "E" opened. Third—This circuit is completed when a car passes out of the block. The controller switch is operated to its normal position and current flows from the feed wire at station "A," through a resistance, through the controller switch, through contacts "RN" on the controller, through contacts "E," through contacts "LR," through the line relay at station "A," over line wire 2, through the line relay at station "B," contact "LR" on the controller, through contacts "H," through contact "RN" on the controller, through the controller switch and through a resistance to ground. This circuit energizes the line relays and allows both signals to operate to the "clear" position. Contact "H" is closed only while the car is on the insulated sections when passing out of the block. As the signals assume their "clear" position, the contact "E" at station "B" is closed so that after the car which is passing out of the block has passed off the insulated sections, contact "H" is opened and the line relay circuit is maintained, as first described above, through the contacts "E."

The following are track relay and controller circuits: The circuit between the setting relay and setting magnet on the controller is opened by contact "G" when the signal is in the

"stop" position. Whenever the signal is in the "stop" position the block is occupied and both line relays are de-energized. If the signal at station "A" is at "stop," the signal at station "B" is at "caution," so that a car entering the block at station "A" operates the setting relay at station "A" and completes a circuit through the setting magnet of the controller at station "B" as follows: Current flows from the feed wire at station "B," through a resistance, through the setting magnet on the controller, through contacts "G" at station "B" to the setting relay at station "B" (but not through the contacts on that relay), then through the back contacts of the line relay at station "B," over line wire 1, through the back contacts of the line relay at section "A," through the contacts of the setting relay at station "A" to ground. This operation of the setting relay at station "A" causes the setting magnets on the controller at station "B" to operate when the signal at station "A" is at "stop." This movement of a car passing a "stop" signal is an irregular movement and contrary to signal practice and operating rules and should not be made except under orders from the dispatcher.

Whenever a car passes out of the block and operates the release relay it energizes the release magnet of the controller at both ends of the block. From the description it is evident that only one controller has been operated and the other controller is in the normal position. The controller that has operated is moved back one step toward normal and the controller that is in the normal position is not affected except that the contacts "H" are closed. Circuits of the release relays and the release magnets on the controller are connected by line wire 3, so that the operation of either release relay energizes both controller magnets. It is evident, then, that a car may pass out of either end of the block and be properly counted out and that as the last car passes out at either end of the block the signals will operate to the "clear" position.

The only functions of the contacts "H" are to complete a circuit which energizes the line relays as the last car passes out of the block, as described above. These contacts are required only while the car is on the insulated sections. There is but one of these contacts required at a time and that is the contact at the end of the block where the signal is in the "stop" position. The lamps in each signal burn continuously and are connected in series with a resistance between the feeder connection and ground. The wiring in the two signals is the same except that the apparatus which is connected in series over lines 1 and 2 is connected to the feeder wire at station "A" and to the ground at station "B."

EUREKA SIGNAL SYSTEM.

The signal system for electric roads made by the Eureka Automatic Electric Signal Co. consists of lamp or disc signals, an electromagnetic controller, and a trolley contactor for controlling the operating circuit when a car enters and leaves the block. Fig. 636 shows the control circuits for the system as first installed, using lamp signals. Two controllers are used for each section of track. These do not operate in synchronism. When a car enters a section the controller at the entering end operates to set the signals to stop at both ends of the section. cars, and the home at that end will be locked at "stop," so that the car in the block will be protected by two signals, blocking cars coming from the opposite direction. Additional cars may follow the first car into the block. In such case the signals will remain as set by the first car, but in the home signal at the entering end of the section, the lights will change with each car taking the block. When two cars attempt to enter a block at opposite ends at the same time, neither can clear the home; or if there is a difference in the time of such attempt, the first car in the block will set the home at its end and lock the other home at stop, and at the same time set the distant at the far end of the block. Should a car go into a block against stop signals, both homes will be set at stop before the overrunning car can pass that at its end, and will remain so until one of the cars backs out of the block, when the system will be automatically set to protect the car remaining in the block.

The signal line, extending from end to end of the block, passes across the base of the controller through switches A, D, C and

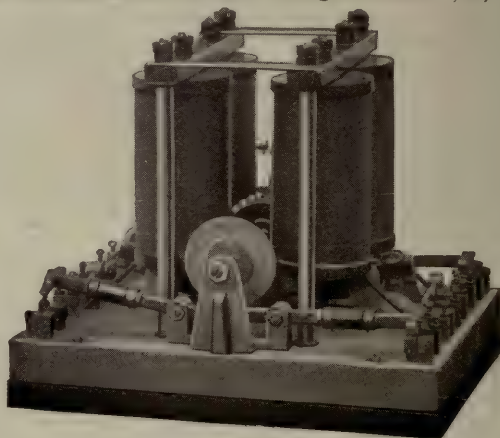


Fig. 633. Signal Controller. Eureka Automatic Electric Signal Company.

F, and not through the magnets. This signal line, when the block is not occupied, is grounded at both ends through the controllers by means of switch D and wire 8 to the rail. Between each controller and that ground the distants are placed. By means of homes are placed, the signal here is connected to the source of power. On the other side of the controller are two switches, C and F, one of which is always open when the other is closed from which a loop extends some distance into the block, in each branch of which a lamp is wired, both located in the "home" signal, one always being lighted when the other is not.

When both controllers are set to ground, switches D being closed, no current can flow and there can be no operation; and when both controllers are operated to connect the signal line to the source of power, switches A being close and D open, no current can flow and there can be no operation. Only when one controller is operated to close switch A, connecting in that

Fig. 632. Trolley Contact Maker. Eureka Automatic Electric Signal Company.

Should cars attempt to enter the block at opposite ends at the same time, both controllers would operate to counteract each other and the home signals at both ends of the block would be locked at "stop." The upper is the home and the lower the distant signal. When block is occupied both home and distant signals at the entering end of the section are clear and both home and distant signals at the leaving end of the section are at "stop." When block is unoccupied, the home signals at both ends of the section are at stop and the distant signals at both ends are at clear. When the signals are in this position a car may enter a block at either end, provided the home goes to clear when the contact-maker has been passed, if approaching controller the signal circuit through wire 1 to source of power, leaving the ground through the other controller intact, can the home signal, normally at stop, be cleared and the distant put at "stop."

Fig. 636 shows two contact-makers the simpler method of installation; but where spring switches are used in the track which cannot be hand operated, it is preferable to use four contact-makers, two at each end of the block, one placed over each branch of the siding. The use of four contact-makers allows the signals to operate before the car passes through the track switch, which if once passed requires the car to back around the turnout in case it cannot go through the block. The

"direction switches" G B H and G′ B′ H′ normally connect B and G and B′ and H′. The energizing of magnets MM reverses switch G B H and of magnets M′M′ switch G′ B′ H′. When a car enters a block the trolley wheel closes the trolley contactor so that current flows from first half of contact-maker through wire 7 to fuse block, thence through closed "direction switch" from B′ to H′, across base of controller through block H of other "direction switch," thence through upper resistance and magnets MM to ground through wire 2. This cuts the signal line into feed connection and also sets the "direction switch" from BG to BH, so that when the trolley wheel reaches the second half of contact-maker, current will flow through wire 3 to fuse block, thence through "direction switch" from B to H, and continue through upper resistance and magnets MM, causing current to flow from entire length of contact-maker through magnets MM. Additional cars going into the block repeat this operation. When a car has passed through the block, upon leaving it the trolley wheel first makes contact so that current flows from the "finger plate" in connection with wire 3 to fuse block, thence through "direction switch" from B to G and across base of controller through G′ to lower resistance, where the current divides. A portion goes through that resistance and magnets M′M′ to ground, across base of controller through wire 2, thus setting, by means of magnets M′M′ "direction switch" from B′H′ to B′G′. This causes the current, when second half of contact-maker is reached, to flow through "direction switch" from B′ to G′ by way of wire 7 and fuse block, lower resistance, and magnets M′M′ to ground. The other portion of the current which divided at lower resistance, passes out by wire 6 to other end of block through switch O of auxiliary controller, and in by wire 6 to and through lower resistance at that end; thence direct through magnet M′M′ to ground, as previously explained, thus operating magnets M′M′ to cut out the signal line from feed connection. This holds good for cars passing through the block from either end. The current coming in by wire 6 cannot flow along the wire with which it connects at lower resistance because that circuit will be open at the contact maker.

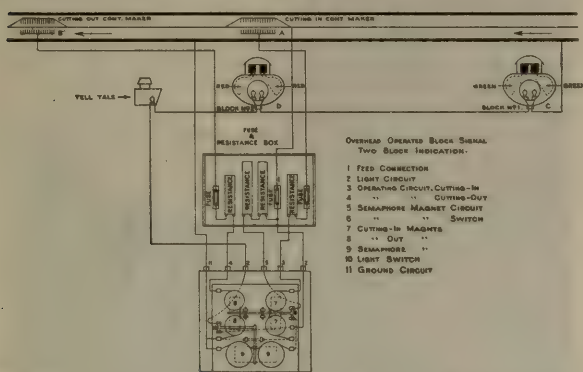


Fig. 634. Circuit for Continuous Block Signal Indication. Eureka Automatic Electric Signal Company.

The function of magnets JJ is to hold switch O open when magnets II are energized to close it, as occurs immediately when the trolley wheel makes contact with the finger plates of contact-maker. They hold it open until the trolley wheel has passed through the entire length of the finger plates. These magnets JJ receive only sufficient current through the resistance in series with them to energize them to hold open switch O, the current being too feeble to operate the main controller through which it continues to ground.

Fig. 635. 12-Inch Disappearing Disk. Eureka Automatic Electric Signal Company.

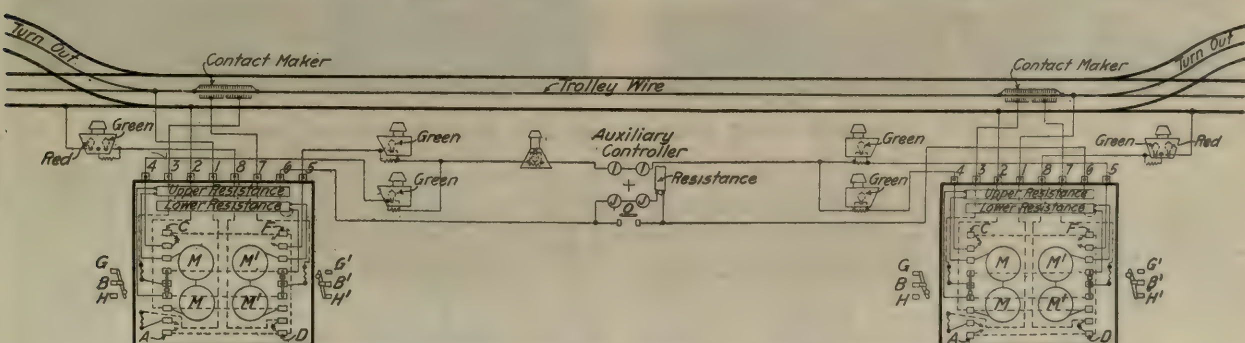


Fig. 636. Signal Control Circuits. Eureka Automatic Electric Signal Company.

When a car has entered the block and the signal line has been cut into the feed connection, the current flowing through it lights the lamps and energizes magnets II of the auxiliary controller to close switch O. This switch thus always closes when cars enter only at one end of the block and pass through and out of it at the other end. Should cars enter at both ends—at one end in defiance of the signals or by overrunning, and thus connect the signal line to the source of current at both ends—no current can flow through magnets II, and switch O will be open.

Fig. 634 shows the control circuits for a continuous block signal indication using the same trolley contactor and controller as described above but giving indications by a 12 in. disappearing disk as shown in Fig. 635. When power in on the line the semaphores are normally at clear, and when the power goes off the semaphores fall to danger. When a car enters the block, the semaphores go to danger and are locked at danger until the car leaves the block at the other end. Should the power go off while the car is in the block, the semaphores will remain at danger until the car leaves the block.

INSTALLATIONS

NEW YORK CENTRAL ELECTRIC ZONE.

The following, which is a description of the latest installation made by the General Railway Signal Co. on the Electric Zone of the New York Central & Hudson River Railroad, illustrates and describes a typical automatic block signal system for a direct current electric road having the heaviest type of traffic, alternating current being employed for the operation of the track circuits and all the signal devices.

The prominent features of this installation are the retention of both rails for propulsion current through the use of iron core reactance bonds; the operation of long track circuits, made possible by the efficiency of the polyphase relays and by the bonds having a higher reactance; the signals of the single-arm, three-position, semaphore type, operating directly over the line; and the general reduction of the amounts of apparatus required.

The 25-cycle, single-phase, alternating current used for the operation of the signal system is normally obtained from the railroad company's 11,000-volt, 25-cycle bus bars, stepped down by means of static transformers, to 2,200 volts for distribution. As a reserve, in case of failure of the 11,000-volt power, motor generators are installed taking power from the railway company's 650-volt storage battery. The switchboard circuits are arranged so that the transformer and motor-generator can operate singly or in multiple as desired.

The substations are located approximately six miles apart, varying in capacity from 60 to 100 k. w. In addition to the power required for the block system, these substations also supply the power for charging the battery, operating motor-generator sets, signal lights, indicators, relays, etc., which are located in the various interlocking plants on the Electric Zone territory.

The transmission line is interrupted between adjacent substations, so that normally each substation feeds out one way, being independent of its neighbor; this is to avoid the need of keeping them in synchronism and to prevent trouble on one section from affecting adjacent sections. In case of emergency, however, the transmission lines can be so connected that a given substation will feed out on to the lines in both directions. On these later installations, aerial transmission lines are used entirely, consisting of No. 0 hard drawn copper wire, strung on the railway company's transmission line poles.

Before taking up the detailed description of the signal appliances it will be interesting to note the advance in the art of signaling during the past five years. The diagram, Fig. 639, shows graphically the amount of apparatus required at a signal location at the present time, as compared with that which was used on the earlier installations which were made on the Electric Zone.

The two-arm, two-position signals used on the earlier work have been supplanted by the single-arm, three-position signals of the Model 2-A type. The Model 2-A signal is operated directly over the line, thereby eliminating the line relays, which in automatic work are ordinarily used to control the signal operation. Group No. 1 of the diagram illustrates the saving due to the use of this signal.

The second group shows a reduction in relays for track circuit control, the four-point Model 1 polyphase relay, replacing the old single point type of polyphase with its Model 19 secondary relay.

The third group shows clearly the saving in gross weight of reactance bonds. This has been brought about by the use of bonds of higher reactance, relays of higher efficiency and the consequent installation of longer track circuits. Therefore, where five years ago, six bonds were required to the mile, but two bonds are now necessary and those of very much smaller size; this resulting in a decrease in weight of the bonds from 3,750 to 925 pounds per mile, or, in other words, a reduction in the ratio of about four to one.

A comparison of transformer apparatus is illustrated by the fourth group, the present transformer being wound to operate not only the signals, etc., but also the track circuits, whereas on the former installations the track circuits were fed by small secondary transformers.

The noticeable decrease in energy consumption from 600 watts (750 volt-amperes) to 200 watts (240 volt-amperes) per signal location is due to the increased efficiency in the signal and track relay apparatus and the elimination of secondary relays, transformers, cut-sections, etc.

Fig. 638 illustrates a typical transformer location, the grid box and transformer being mounted on the pole. As shown on circuits in Fig. 641, transformers are required near signals, at the middle of center-fed track sections, and at the ends of all track sections. Those at the signal locations necessarily have more secondary windings than the others, the secondaries consisting of a coil with taps giving voltages of approximately 170, 55 and 17 for the operation of signals, lighting circuits and relay locals respectively, a 55-volt coil for the local control of relays not located at the transformer in question (see circuits, Fig. 641) and from one to three coils

Fig. 637. Model "2-A" A. C. Automatic Signal Bridge, N. Y. C. & H. R. R. R.

Fig. 638. Transformer and Grid Box on Pole. New York Central Electric Zone.

for track feed, the different taps giving voltages which vary from two to eight volts. The secondary coils are independent of each other, each terminating in binding posts located within the transformer, thus doing away with a number of external leads which may or may not be required. Plug cut-outs are used in the primary circuit so that the transformer may be disconnected from the transmission lines without danger.

Fig. 643 shows a typical installation of the iron core reactance bonds used in connection with double-rail a. c. track circuits. The bonds are wound with 10 turns of copper, having sectional area of 750,000 circular mils, with a continuous carrying capacity per track of 2,000 amperes, a short-time overload of 3,400 amperes, and an unbalancing capacity of over 400 amperes, the latter without varying the reactance over five per cent. The resistance of the bond to alternating current is approximately 1-10 of an ohm. The coils of the bond are immersed in transformer oil.

The copper connections, after leaving the bond terminals, go downward and underground to the rails, where, after passing

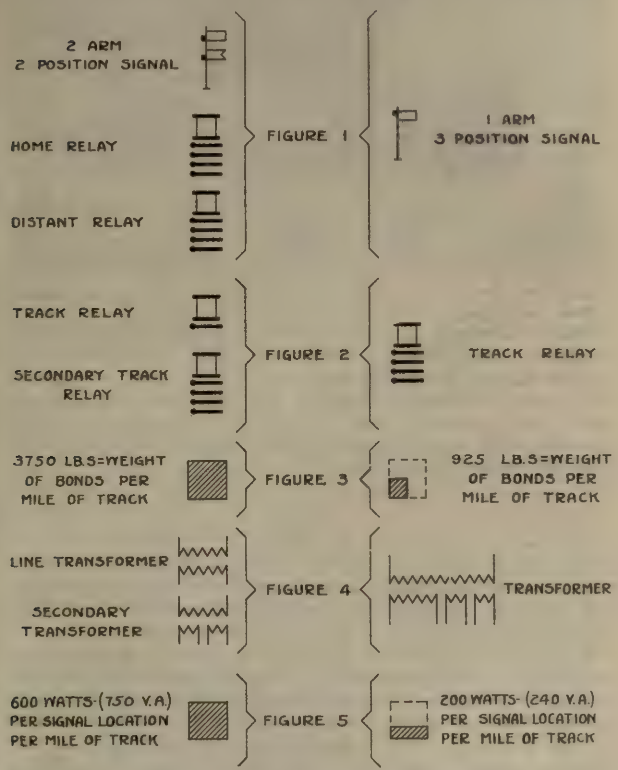


Fig. 639. Diagram Showing Progress Made in Signaling on N. Y. C. E. Z. During Past Five Years.

for a short distance above ground to insure flexibility, they are connected to the rails. The bond connections to the rails consist of two 500,000 circular mil flexible cables in multiple.

The track relay at present employed on the Electric Zone is the Model 1 polyphase, the relay being provided with four front and four back contacts. It is operated by a two-phase induction motor, one phase of which is connected to the rails and the other to the track transformer, Fig. 641. Of the energy in the two relay windings, that supplied by the transformer direct is by far the greater. It, therefore, requires but a small amount of energy from the track to give positive action to the contacts, and as a result, long track circuits can be operated with minimum of energy. The various moving

Fig. 640. Model "2-A" Block Signal. N. Y. C. E. Z.

contacting parts, which are mounted on a horizontal wooden bar, are of unusually heavy construction, having a wide opening, and by rubbing through the last 1-16 in. of their stroke in closing they maintain a clean, low resistance contact. Contacts and all other working parts are visible through glass-covered openings. The relay is insulated to stand a breakdown test of 3,000 volts alternating current.

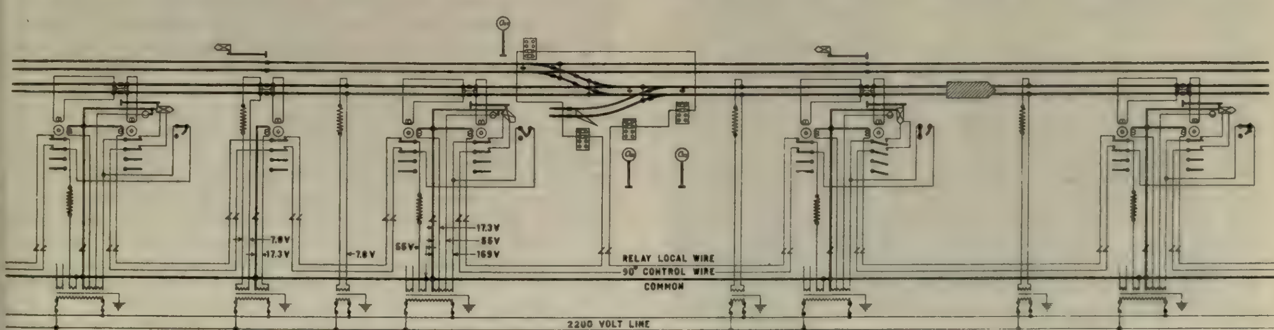


Fig. 641. Typical Arrangement of Circuits for A. C. Automatic Signals. N. Y. C. E. Z.

The signals, as mentioned above, are of the single-arm, three-position, Model 2A type. They are designed to operate on a voltage of 150 a. c., clearing the blade from 0 to 90 deg.

Fig. 642. Track Box Location. N. Y. C. E. Z.

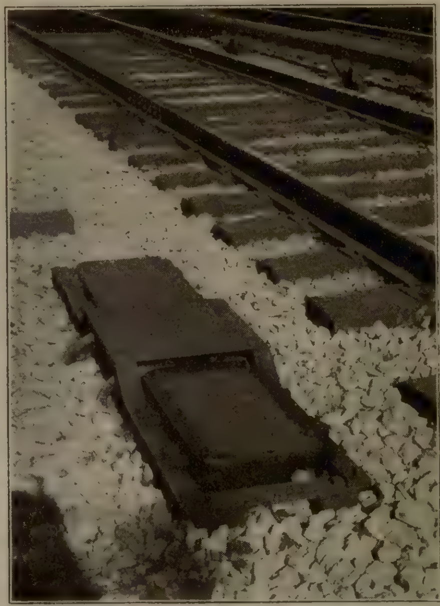


Fig. 643. Double Bond Location. N. Y. C. E. Z.

through three positions in five seconds. As shown in Fig. 641, the signal is controlled locally for the 45-deg. position and over the line directly for the 90-deg. position. A complete description of the signal mechanism is given under Automatic Block Signal mechanisms.

Fig. 640 shows a single automatic semaphore, Fig. 637 a typical four-track bridge equipped with same and Figs. 649 and 650 show views of the type of light signals installed in the Park Avenue tunnels immediately outside of the New York City Terminal.

Fig. 641 shows a complete typical block circuit, four signals being illustrated to present the circuit combinations from clear to stop. Attention is called to the following features: The direct 90-deg. control of the signals; the use of end and center-fed track sections; the practice of restricting switch selection to the local-phase wire of the relay at a signal location, thus keeping the high voltage wires out of the switch boxes; and the protection afforded this local wire against crosses with signal control wires through the use of opposing polarities. To avoid confusion, the detail mechanism wiring for the signals is omitted (see page 76), it being understood that when current is applied to a control wire, the arm will clear. The various devices represented in Fig. 641 have been described and the operation of these circuits will be evident without further explanation.

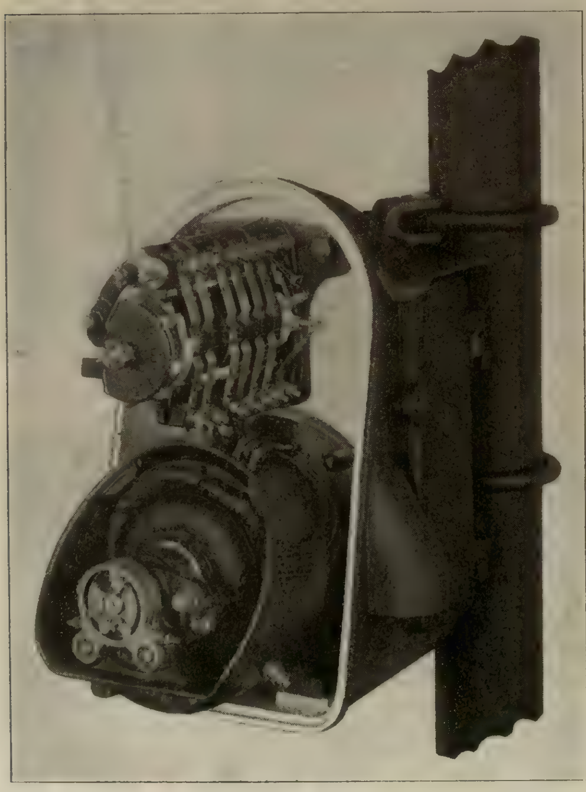


Fig. 644. Universal Model "2-A" Direct Connected Signal Mechanism, A. C. Commutating Motor. General Railway Signal Company.

LEHIGH VALLEY TRANSIT COMPANY.

The Lehigh Valley Transit Co. operates a high-speed single-track electric line, using direct current at 600 volts for traction purposes. On a section of this line is installed the G. R. S. Co.'s "Absolute Permissive" block system of signaling.

Energy for the operation of the signal system is stepped down by type "H" transformers at all track feed and signal locations, from the 2,300-volt, 25-cycle transmission line along the right-of-way. The transformers are provided with a 55-volt winding for the operation of the signals, for relay locals, and for the lighting circuits, and with independent windings having a range of from two to six volts for the various track circuits.

Double-rail track circuits, using iron bonds, are installed between sidings and single-rail circuits on the short sections through the sidings. Fig. 648 illustrates the installation of a reactance bond where a two-rail track circuit abuts with a single-rail circuit. Fig. 645 shows a double bond location where two double-rail circuits are adjacent.

By bonding together the power rails of the two tracks in the sidings, two rails are made available for the return of the propulsion current throughout the signaled territory.

The relays installed are the G. R. S. Co.'s Model 2, Form A polyphase. On one center-fed track circuit two miles long this relay required but four volts and 10 amperes (40 v. a.), the section having dirt banked up near to the top of one rail throughout its entire length and up to the top of both rails at the 20-odd road crossings within the section. In another center-fed track circuit, 4,000 feet long, the track conditions are as illustrated in Fig. 646. Furthermore, a reactance bond is connected across the rails near the center of this section, to provide a negative return for another branch of the company's lines. This track circuit requires five volts and 22 amperes (110 v. a.) for strong relay operation, the major portion of this current flowing through the reactance bond at the center of the track section.

The signals are G. R. S. Model 2A, operated by 55 volts. 25 cycle a. c. In order to prevent delay to the following sections of a train, a permissive indication is given which consists of a yellow light displayed half way up the signal mast. When a car has entered the block and put the signal arm to the stop position the cautionary yellow light will be shown, advising a car following, that another has preceded it and that it is safe to enter the block under caution.

The signals governing in one direction normally stand at

danger and in the other in the clear position, the control of the normal clear signals overlapping that of the opposing normal

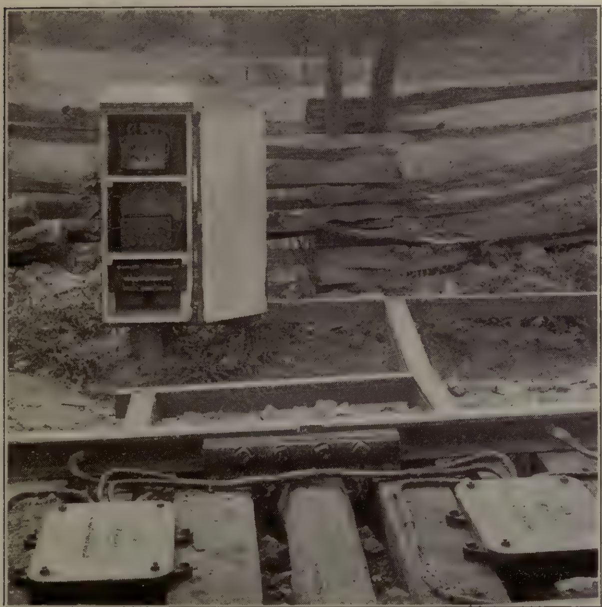


Fig. 645. Track Feed Location. Lehigh Valley Transit Company's Railways.

danger signals through the preliminary clearing section, as shown in the first diagram of Fig. 647. Opposing signals governing into a given piece of single track are electrically interlocked in such a manner that one must be at stop before the other can give either a proceed or permissive indication. The

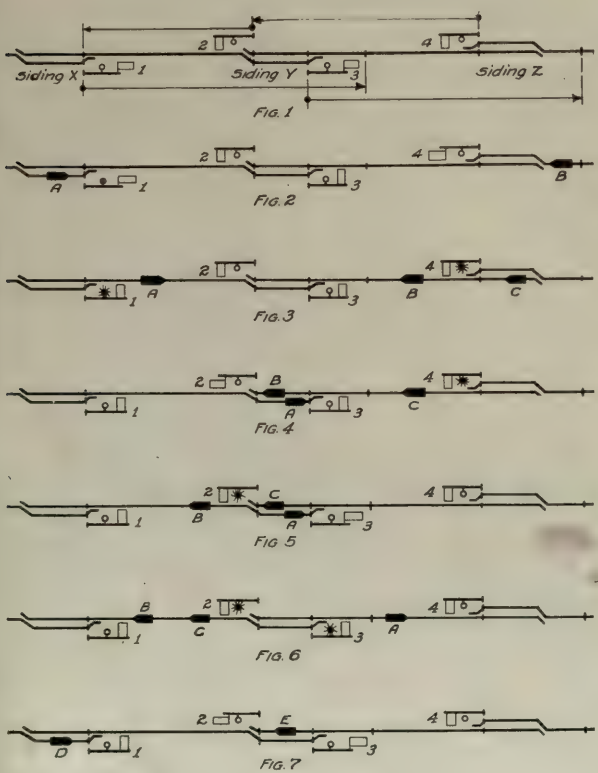


Fig. 647. Diagram Showing Train Operation. Lehigh Valley Transit Company's Railways.

circuit prevents a false proceed or permissive indication being given through breaks or crosses in the line.

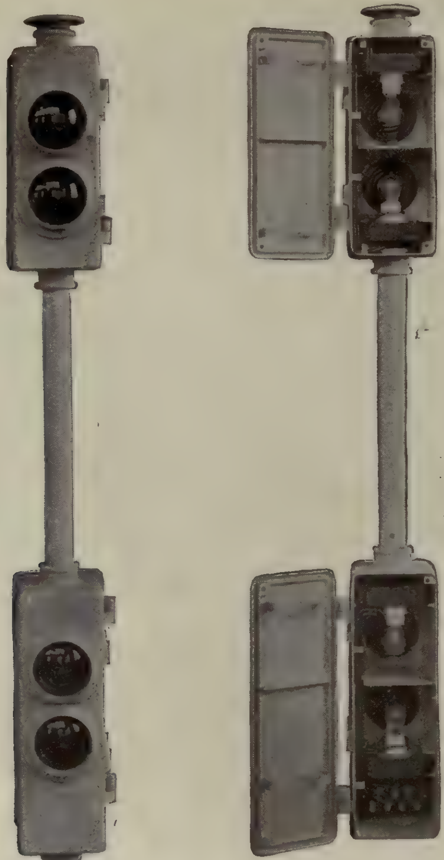
The series of diagrams show train "A" approaching and passing trains "B" and "C," running in two sections. The last figure in the diagram shows train "E" at a predetermined meeting point and having a clear signal, thus holding train "D"

Fig. 646. Typical Section of Track. Lehigh Valley Transit Company's Railways.

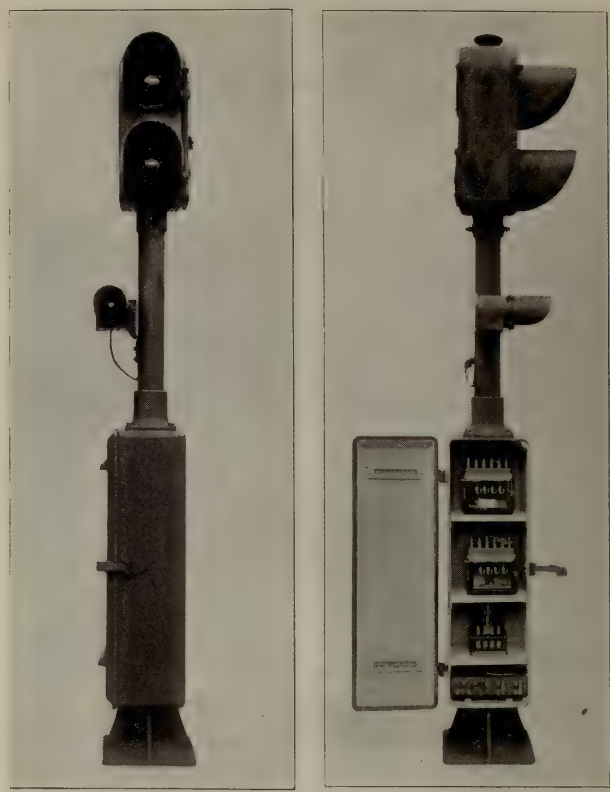
at the next siding. The conductor of train "E" by inserting a key in a small box, located near the signal, can place signal 2 at stop, thus permitting signal 1 to clear, advancing train "D"

Fig. 648. Single Bond Location. Relays Housed at Base of Signal. Lehigh Valley Transit Company.

to the regular passing siding. After "D" has passed, the motorman or conductor on train "E" must turn the key back and withdraw it before signal 2 can be cleared again, to allow his train to leave the siding.



Figs. 649-650. Light Signal, Park Ave. Tunnel, N. Y. C. E. Z.



Figs. 651-652. G. R. S. Light Signal—Day and Night Indications. Arrestive Indication Given from 1,200 to 1,500 ft. in Bright Sunlight and with Covering of Fresh Snow on Ground.

HUDSON & MANHATTAN RAILROAD.

The signaling in the Hudson tunnels covers the four miles of double-track road between the station at 33d street, New York, and that at Hoboken, N. J. The system is designed to provide for a two-minute interval service and affords to a train the protection of three home and four distant signals. Automatic stops are installed to prevent a train overrunning a home signal when in the stop position.

shown in Fig. 658, the relay box is mounted above the case containing the control apparatus for the automatic stop. Fig. 661, illustrating a typical signal location, shows the relay box, junction boxes and transformer at the back of signal 160, and the automatic stop and reactance bond between the rails of the track.

Light signals of the shutter type (Fig. 659-660) are installed, one case housing both home and distant mechanisms.

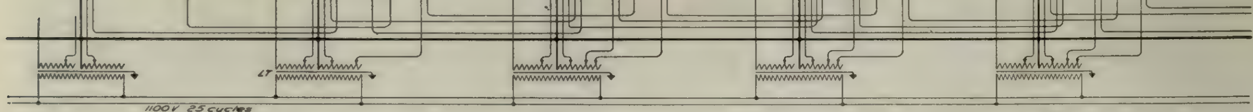


Fig. 653. Diagram of Block Signal Circuits. Hudson & Manhattan Railroad.

Names of Parts of Fig. 653.

A *Resistance Coil*
B *Iron Core Reactance Bond*
C *Contact Closed by Automatic Train Stop*
D S *Distant Signal*
G *Resistance Grid, Adjustable*
H S *Home Signal*
L T *Line and Track Transformer*
R *Reactance Coil*
T R *Polyphase Track Relay*

The tracks are paralleled by a 25-cycle, 1,100-volt line, this voltage being stepped down by G. R. S. Type "H" transformers at the signal locations to the various voltages required for the operation of the system.

Both rails are retained for the return propulsion current by the use of iron core reactance bonds (Figs. 654-655). The track relays are the G. R. S. Co.'s Model 1 polyphase. As

The shutter which passes between the electric lights and the signal lenses is actuated through a gear and pinion movement by a two-phase induction motor (Figs. 656-657), similar to the Model 1 polyphase relay. Each signal is lighted by two incandescent lamps, connected in multiple and arranged so that should one be extinguished the other will continue to throw light through both of the signal lenses, giving an

Fig. 654. Reactance Bond, Hudson & Manhattan Railroad.

Fig. 655. Reactance Bond, Coils and Core. Hudson & Manhattan Railroad.

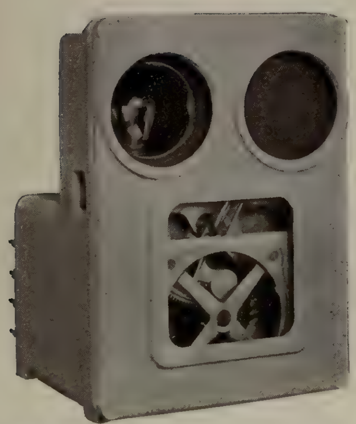


Fig. 656. Front View of Tunnel Signal Mechanism. Hudson & Manhattan Railroad.

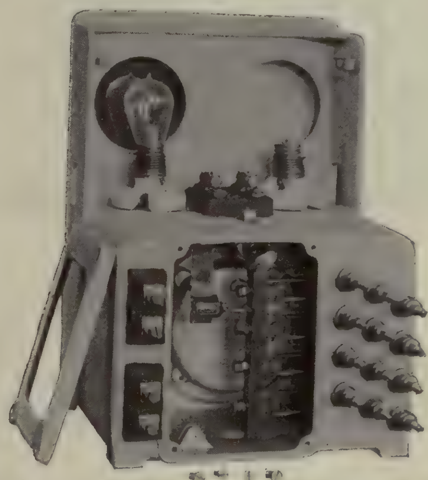


Fig. 657. Rear View of Tunnel Signal Mechanism. Hudson & Manhattan Railroad.

Fig. 658. Relay Box; Train Stop Control Apparatus in Bottom Compartment. Hudson & Manhattan Railroad.

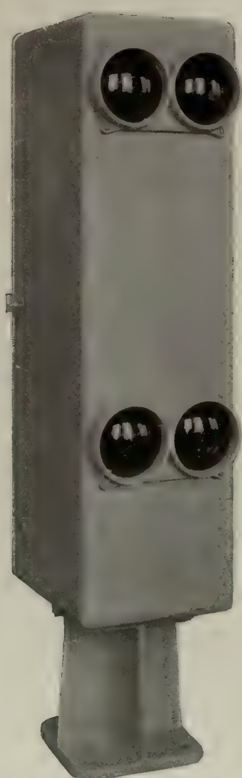


Fig. 659. Front View of Tunnel Signal, Hudson & Manhattan Railroad.

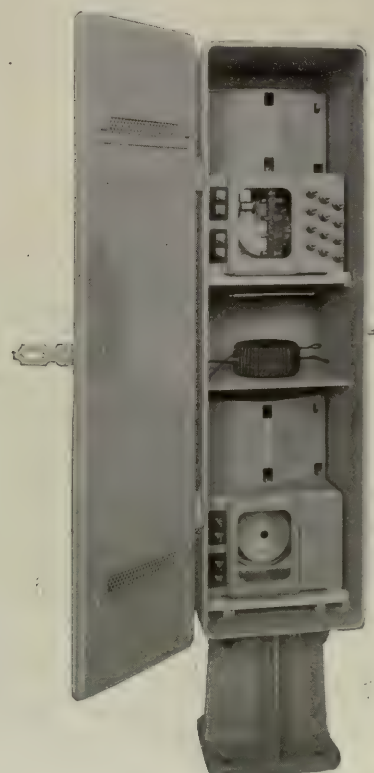


Fig. 660. Rear View of Tunnel Signal with Door of Case Open. Hudson & Manhattan Railroad.

indication of reduced intensity, so that the trouble will be observed and the lamp replaced. The home mechanism is equipped with the contacts necessary to the control circuits shown in Fig. 653.

It will be seen by referring to the typical circuits (Fig. 653) that the home signals are controlled by a double overlap,

Fig. 661. Union Light Signal. Hudson & Manhattan Railroad.

and the distant signals through the home signal in advance. The control circuit for the home signal is so broken through the contact on the automatic stop that it may be cleared only when the stop is in such position as to allow the passage of a train. To simplify Fig. 653, the wiring and control circuits for the automatic stops are omitted.

SUSPENDED LIGHT SIGNALS ON PENNSYLVANIA TERMINAL.

With what may be regarded as perpetual night conditions within the tunnels and in the larger portion of the terminal track area, the use of signals having arms or blades for defining their positions was of secondary importance on the Pennsylvania Tunnel & Terminal signal work. This fact, coupled with the usual close quarters encountered in such places, prompted the total elimination of the arms from all block signals in the tunnels and from all but the ground or dwarf signals on the terminal area.

The form of signal which was used, therefore, had need for

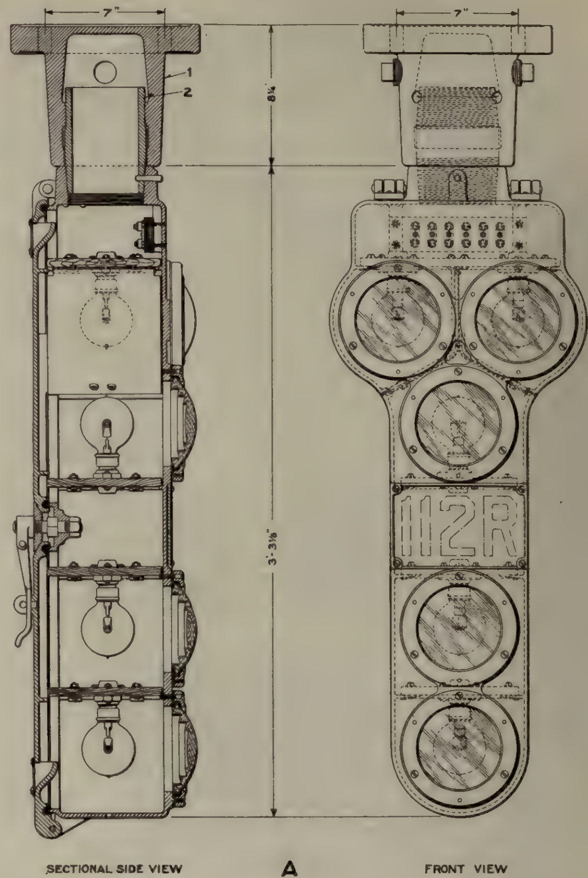


Fig. 662. Suspended Five-Light Electric Light Interlocking Signal. Union Switch & Signal Company.

no other mechanism than that required for changing the colors of a system of stationary lights in such a manner as to reproduce the same colors and combinations as these produced by changes in position of the semaphore type of signal under like changes in the controlling currents. These signals are, therefore, simply receptacles carrying colored lenses behind which

Fig. 663. North End of the Hudson River Tube. Pennsylvania Tunnel and Terminal Railroad.

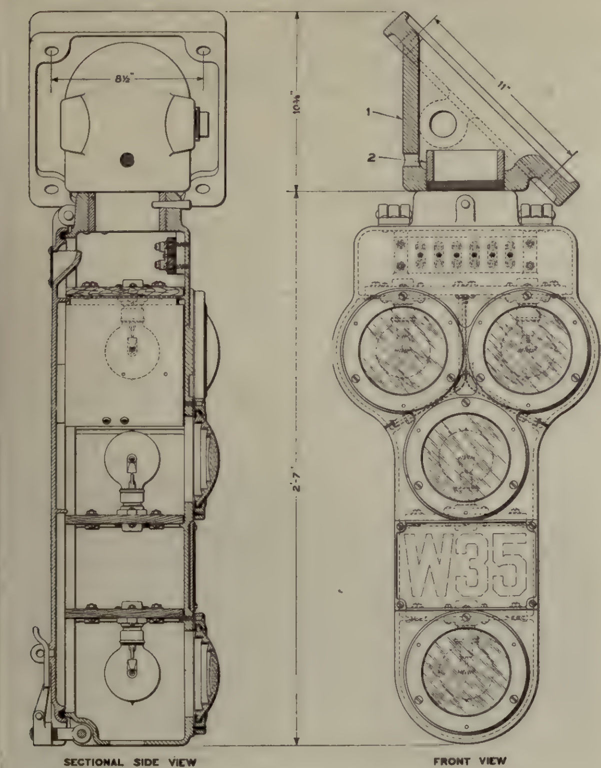


Fig. 664. Suspended Four-Light Electric Light Automatic Signal. Union Switch & Signal Company.

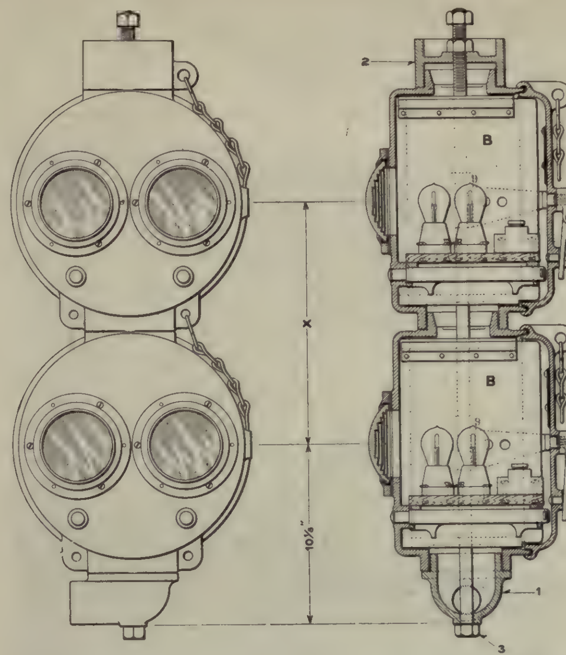


Fig. 665. Multiple Unit Electric Light Signal with Cap. Union Switch & Signal Company.

are located standard four candle-power incandescent lamps (two in multiple for each lens), and the "mechanism" consists of simple relays (housed in separate shelters near the signal) the contacts of which were adapted to shift the current from lamps to lamps and thus to change the colors displayed as the relays are energized and de-energized.

WASHINGTON WATER POWER COMPANY'S RAILWAYS.

This installation, made by the General Railway Signal Company, covers 20 miles of single track between Spokane and the towns of Medical Lake and Cheney, in the state of Washington. The installation consists of a. c. signals equipped with automatic stops of the overhead type, double-rail track circuits using iron core reactance bonds, polyphase relays, etc., the system operating on the principles which are described under the heading, "The Alternating Current Track Circuit." The installation may be said to be similar to the one on the New York Central Electric Zone (page 104) with certain modifications and additions which are covered herein.

any line is less than 10 per cent, even though all the signals were cleared at the same instant. The line is protected at half-mile intervals with suitable high tension lightning arresters.

Model H transformers, made by the General Railway Signal Co., are installed at signal and track feed locations to step down from the 2,200-volt lines to the various voltages required for the operation of the signal system. Independent secondary windings are provided for each track circuit and for the signal operating, lighting, and relay local circuits. Track secondary windings are furnished with taps ranging from one and one-half to eight volts, the different voltages being necessary to meet the requirements of varying lengths of track sections; the signal secondaries provide 220 volts for signal operation with taps of 55 volts for signal lighting and 28 volts for the relay local windings; all of which taps are taken to a terminal board for convenient connection to the external circuits. The transformers are mounted on stub poles as shown in Fig. 671.

Two-rail track circuits are used so that both rails are available for the returning propulsion current, the track being divided into block sections of from 175 ft. to 15,150 ft. by the means of insulated rail joints and reactance bonds. On account of the fact that the trains operated are not as heavy, nor the service as frequent, as on the New York Central Electric Zone, a much smaller reactance bond is used. The method

Fig. 666. Typical Circuits. Washington Water Power Co.'s Railway.

The cars are operated by 600-volt direct current obtained from motor generator sets supplied from the 60,000-volt, 60-cycle line paralleling the track. Sixty-cycle alternating current is used for the operation of all parts of the signal system, current being available at a power substation located approximately in the center of the district to be served. The current is delivered to the bus bars of the signal switchboard at 2,200 volts, whence it is distributed to the transmission lines through automatically tripped oil circuit breakers equipped with I. T. E., time limit relays and alarm bell. The transmission line consists of two No. 10 H. D., T. B., W. P., line wires strung under the main transmission line on the same poles, this size having such carrying capacity that a maximum drop at the end of

of installation of these track bonds between the rails is shown in the illustration, Fig. 671.

The relays used in connection with the track circuits are the General Railway Signal Co.'s Model 1 polyphase, being provided with four front and four back contacts. The relay's efficiency has been demonstrated by its perfect operation over continuous track circuits approximately three miles long and in the absence of the best conditions as to ballast and track leakage.

The signals installed are of the Model 2 A type, operating through two positions, 0 to 45 deg., in the left-hand upper quadrant. This being a single track line, the signals are suitably overlapped to provide the desired protection. Distant signals are installed where the view of a home signal

is obstructed on account of curvature or heavy grades. As shown in Fig. 666, signals operate directly over the line without the use of line relays, the longest distance over which a signal is so controlled, on this installation, being about three and one-half miles.

The automatic stop is of the overhead type and consists of an auxiliary arm, mechanically connected to and operating in unison with the arm of a home signal, the auxiliary arm being so placed that when the signal is in the stop position a train cannot pass without breaking against it a glass tube mounted on the roof of the motor car. The breaking of this tube, which is directly connected to the train line, reduces the air pressure, giving a service application of the brakes. The brakes, having been so set, can only be released by the replacement of the broken tube; a limited supply of and strict accounting for these tubes form the most effective check on the observance of signals. To provide for the necessity of a train passing a signal in the stop position, means are provided whereby the arm may be raised by hand for the passage of a train, this being accomplished by the insertion of a key in a lock provided for the purpose, which key cannot be removed until the signal arm has again been restored to the normal position.

Fig. 667. Model "2-A" A. C. Signal. Arm at Proceed.

Fig. 668. Model "2-A" Signal. Arm at Stop.

The line is paralleled by a telephone system, and all motor cars are equipped with a telephone. In case a train crew finds a signal set against them, they can get into communication with a dispatcher by plugging into the telephone jack at any signal location and so get the necessary orders to proceed or wait, as the case may be. During a period shortly after the installation of the signal system, when considerable trouble was experienced with the telephone line, it was found that the train crews were able to maintain their schedules and operate their trains with perfect safety, using the block signals as their only guide.

Fig. 669. Automatic Stop Tube Shown in Place on Top of Car in Figs. 667-668.

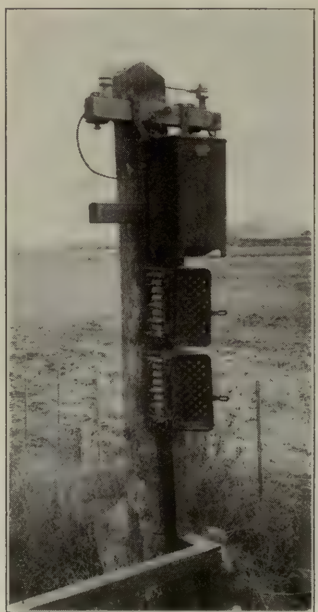


Fig. 670. Track Feed Location. Resistance Grids Mounted Below Transformer.

Fig. 671. Location Showing Method of Installation of Transformer, Relay and Grid Boxes and Reactance Bonds.

SAN FRANCISCO, OAKLAND & SAN JOSE CONSOLIDATED RAILWAY (THE KEY ROUTE).

The San Francisco, Oakland and San Jose Consolidated Railway operates between Oakland, Berkeley and Piedmont, connecting with ferry service to and from San Francisco by running over a double track line to the end of a pier extending three miles into San Francisco Bay from Oakland. The traffic is intermittent in character, four or five trains leaving

Fig. 672. Model "2-A" A. C. Signals Mounted on Trolley Poles. Key Route.

a few seconds apart from the pier terminal shortly after the arrival of each ferry. The trains, which operate on 600 volts direct current, are made up of from four to eight cars, multiple unit control being used. Running from the pier terminus to the mainland, the trains accelerate until they reach a speed of about 35 miles per hour, whereas, in running in the other direction, the speed is maintained approximately at 35 miles for the whole distance. Over the four miles of road from the pier terminal to the junction of the lines leading to Piedmont and Berkeley, signals have been installed of the three-position, upper quadrant type, being so located as to permit the trains to operate under a headway of 45 seconds at the speeds encountered on the various parts of the line. Automatic train stops of the overhead type provide for service applications of the brakes should a train attempt to pass a signal set at stop. This installation was made by the General Signal Company.

Motor generator sets, located at one of the traction power houses, furnish 1,100-volt, 25-cycle alternating current to the signal transmission line. This is stepped down at track feed and signal location by Model H transformers to the various voltages required for the operation of the signal system, but 10 k. w. being required for the entire installation, consisting of 75 signals with their controlling devices and track circuits. Signal transformers and relay boxes are located on the center poles which support the trolley wires, connections between transformers and relay boxes and between relay boxes and signal mechanisms being made through lead-covered cables. This is necessary as a protection against the salt spray, which at times reaches the deck of the pier. Lead-covered wire is also used between the relay boxes and the rails.

On account of the fact that a headway of 45 seconds is maintained, the track circuits are so short that it was found economical to use single rail track circuits, the continuous rail being supplemented by a 1,000,000 circular mil copper conductor to assist in carrying the return propulsion current. The track relays are of the General Railway Signal Co.'s Model 1 polyphase type, equipped with four front and four back contacts.

The signals are the G. R. S. Model 2 A, operating on 55-volt alternating current. The mechanisms are controlled directly over the line without the intervention of a line relay, taking the 45-deg. position through the track section immediately ahead of the signal, and the 90-deg. position through the signal in advance, at 45 to 90 deg.

The automatic stop feature consists of a metal arm supported at a height slightly above the car and operated by the signal

Fig. 673. Model "2-A" A. C. Bridge Signals. Key Route.

mechanism, this arm, whenever the signal is in the stop position, engaging the trip arm of a specially designed valve mounted on the roof of the motor car. The tripping of this valve is designed to reduce the pressure on the train line, thereby giving a service application of the brakes. The valve is restored to its normal position by the reduction of pressure in the train line to a predetermined amount by the use of the motorman's brake controller. The arrangement is such as to give the proper application of air through the brakes, irrespective of how the motorman may manipulate his controller either to charge or discharge the train line. When running against traffic, the trip arm, after engaging the first stop arm, is arranged to be held down in the reverse position until released by reducing the air pressure to the predetermined point referred to above. Arrangements are provided whereby the trainman can "key-by" if it becomes necessary to pass a semaphore in the stop position. This is accomplished through unlocking the stop mechanism and holding up the stop arm until the train has passed by. The key cannot be removed

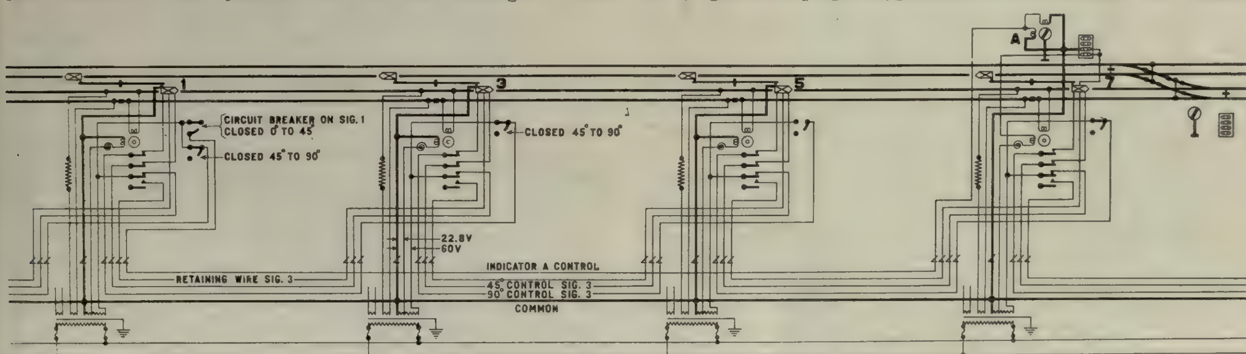


Fig. 674. Typical Circuits S. F. O. & S. J. C. Ry.

from the lock until the stop arm has been lowered to the full stop position again, so that it will set the trip and operate the air valves on the cars of the following train.

Because of the foggy weather encountered during certain portions of the year and the severe traffic conditions imposed on the road, the train schedules suffered not infrequently before the installation of the signal system. The installation was made only after a close study of the operating conditions, and, being based on the results of careful tests as to braking distances, speeds at different points, etc., it has placed the road in a position to operate its trains with facility and safety under the worst weather conditions and during the periods of heaviest traffic.

INTERBOROUGH RAPID TRANSIT COMPANY'S SUBWAY DIVISION.

The arrangement of block signals installed on the Subway Division of the Interborough Rapid Transit Company consists of the automatic overlapping system shown in Fig. 675, applied to the two middle express tracks and to the third track on the west side branch. This third track is placed between the two local tracks, and is used for express traffic in both directions. The apparatus used differs little in general principle from that employed in earlier automatic systems of block signaling, the substitution of alternating current in place of battery current for the track circuit, and the necessary alternating current auxiliary apparatus, constituting the principal change. In detail of application to the peculiar requirements under subway conditions, however, the system embodies many radical features.

In Fig. 675 is shown a diagram of the block signal and automatic train stop circuits as used in connection with the overlapping feature of this system.

In this system of signaling one of the running rails of each track is insulated from the propulsion-current return system and is devoted to signal purposes. Thus, the other rail performs the function of serving simultaneously as conductor for the direct-current return for the propulsion system, as well as that of one of the conductors for the alternating-current track circuit for controlling the signals. The current is fed into each block at the end from which the passing train leaves it, the connections to the signal-control apparatus being made from the opposite, or entering, end of the block, as shown in the circuit diagram. The track connections at the signal end of the block lead from the track circuit to the alternating-current signal-control relay, which operates secondary connections in the various circuits of the signaling system. This relay operates double contacts, so that when the block is clear and current is thus passing through it, two separate circuits are closed; one of these is the circuit leading to the automatic train stop at the entrance to the block in the rear.

The distant, or caution, signals are operated by an auxiliary circuit as the result of the setting of the home signal. When the home signal of a block is clear, current passes through the control mechanism of the distant signal of the preceding block, thus holding it clear also. When the home signal is changed to the stop position the current flowing in the auxiliary circuit is interrupted by a circuit controller on the home signal, which causes the distant signal to indicate caution.

The alternating current for the track circuits is supplied by high-voltage alternating-current mains which run the entire length of the tunnel. These deliver current to the signal blocks at 500 volts potential, from which it is stepped down at each block by a double-secondary oil transformer, one coil of which feeds the track circuit and the other the signal-lamp circuit. The magnet-control apparatus, which is used for operating the controlling air valves for the signal cylinders, receives current from a storage-battery main which also runs the length of the subway. This main is fed by several sets of 16-volt storage batteries in duplicate, which batteries are located at the various interlocking towers and are charged by motor generators.

In Fig. 685 is shown the arrangement of the apparatus installed at a block-signal location. It consists of the block signal, the transformer, a case for the track-circuit instruments and the automatic stop valve box. The transformer takes current from the 500-volt main through three-amp. enclosed fuses to the primary coil; its secondary contains two coils, one of which delivers current at 50 volts for use in the four c. p. incandescent lamps used in the signal, while the other coil delivers current at the lower voltage (10 volts) for use in the track circuit. The leads to the track circuits pass down the instrument case and thence to the rail connections at the exit end of the block; in the instrument case they pass through non-inductive grid-resistances of one ohm, which serve to prevent any large amount of current from flowing through these circuits in case of abnormal disturbing conditions in the propulsion return current, and also prevent an excessive alternating current passing from the transformer when short-circuited by the presence of a train in the track circuit which it feeds.

The alterating-current track relay is shown in Figs. 680-684. The principle of operation involved is that of the action of an alternating-current field upon a slotted metallic (non-magnetic) vane, which is caused to move in such a way as to close the two circuit contacts. The alternating-current field is supplied by a magnet of laminated field-core construction, with the field coils arranged very close to the pole faces. The vane, which is of aluminum, is pivoted in a vertical position on jewel bearings. The upper half of each pole piece is enclosed by a copper ferrule set into a notch. The ferrule is so arranged that half the lines of force in the field must pass through it. Any change in the number of lines of force through the ferrule will set up an electromotive force in the ferrule acting to produce a current. The direction of this current will be opposite to that producing the change in the field and will itself tend to produce lines of force in opposition to the field. In other words, changes from zero lines of force to maximum and back to zero will be retarded in the "shaded" or ferrule-enclosed half of the field. This will cause the magnetic flux to shift from the lower to the upper portion of the field at each reversal of polarity. Now currents are generated about the slots in the vane by the field flux the same as in the ferrule. These currents will produce fields of their own opposite to the main field, and will act against the main field and be repelled by it in the same manner as like magnetic poles. But the shifting flux in the main field due to the ferrules is constantly moving upward. Therefore the vane is raised. The action is similar to that between fields and squirrel-cage armature in a polyphase induction motor.

The track relay and associated apparatus are housed in a cast-iron instrument case of water-tight construction, as shown in Fig. 685. This consists of two sections, the lower part containing the relay and connections, and the upper part the

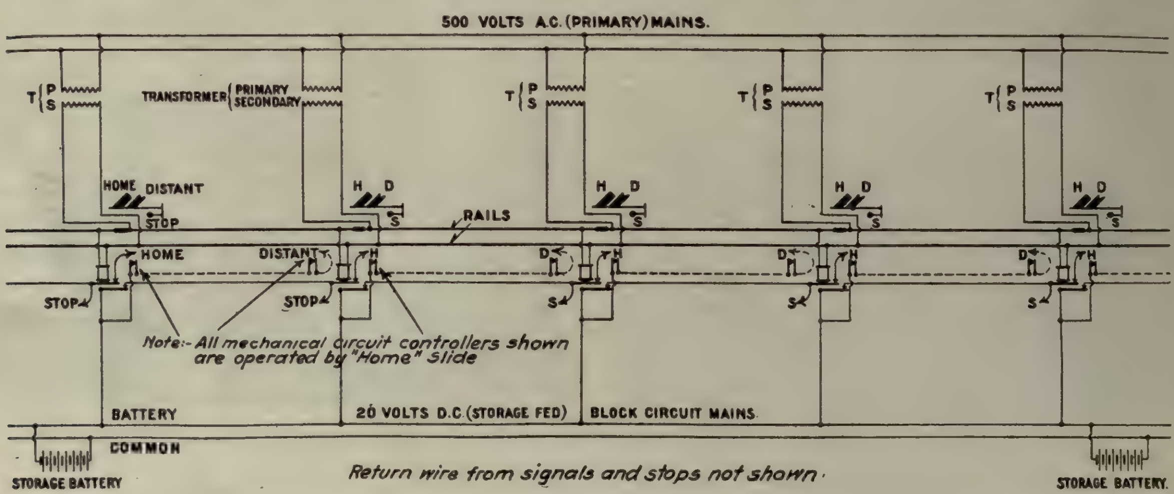


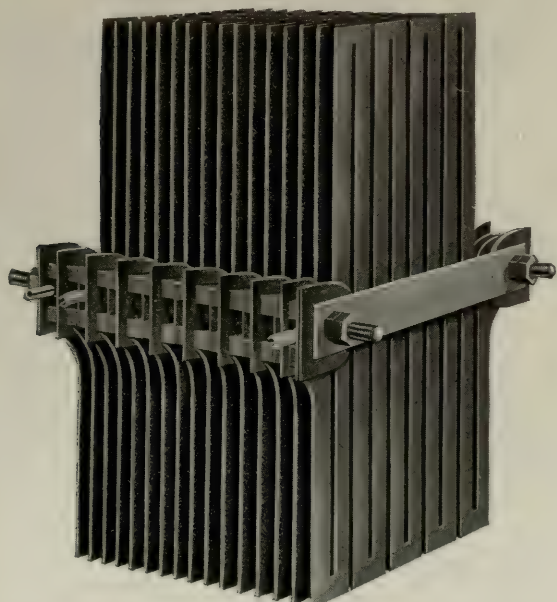
Fig. 675. Diagram of Signal Control Circuits. Interborough Rapid Transit Company.

grid-resistances, Figs. 678-679, which are connected, one in series with the transformer supplying alternating current to the track circuit, and the other in series with the track relay.

The impedance coil, Fig. 677, is connected in multiple with from which connections are made to the distant signal mechanism in the preceding block and to the automatic stop, as well as to the storage-battery mains for the direct-current supply for the signal mechanism. Four conductors lead out to make

Fig. 676. Track Transformer Coils and Core. Union Switch & Signal Co.

Fig. 677. Impedance Coil Used on Single Rail Alternating Current Track Circuit.



Figs. 678-679. Non-inductive Resistance Grids Used in A. C. Track Circuits.

the track relay and shunts out any propulsion current that might have a tendency to pass through it.

A seven-conductor cable leads to the signal nearby, while another seven-conductor cable leads to a junction box the necessary connections with the rails on each side of the insulated joints.

The signal (Figs. 690 and 691-692) consists of a vertical iron case fitted with two white lenses, the upper being

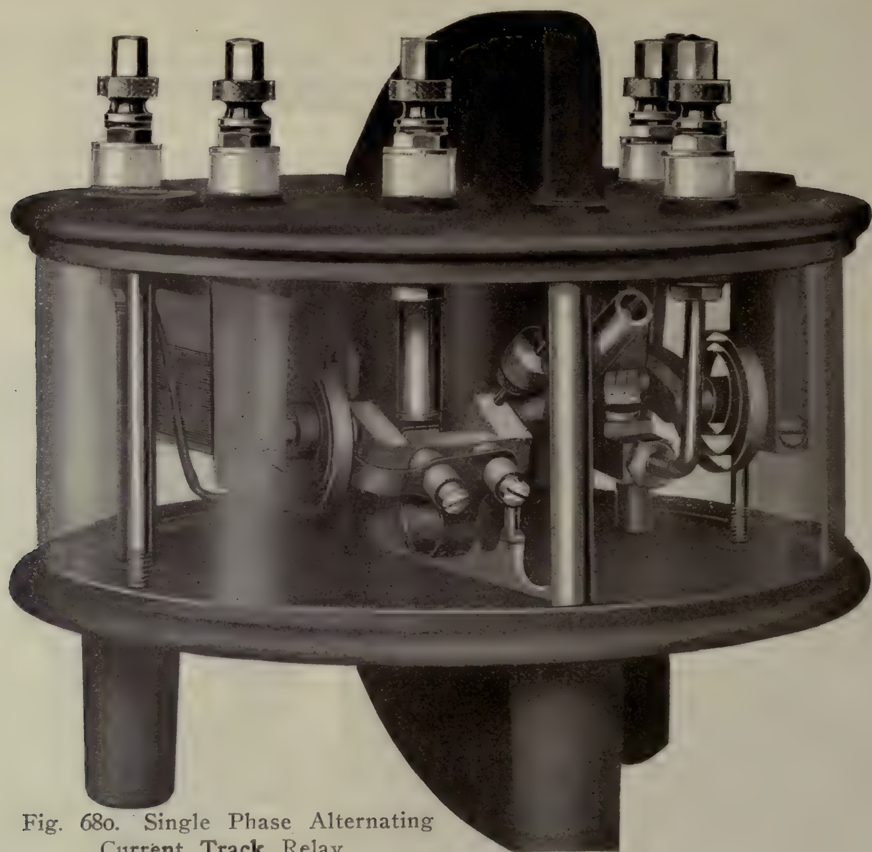
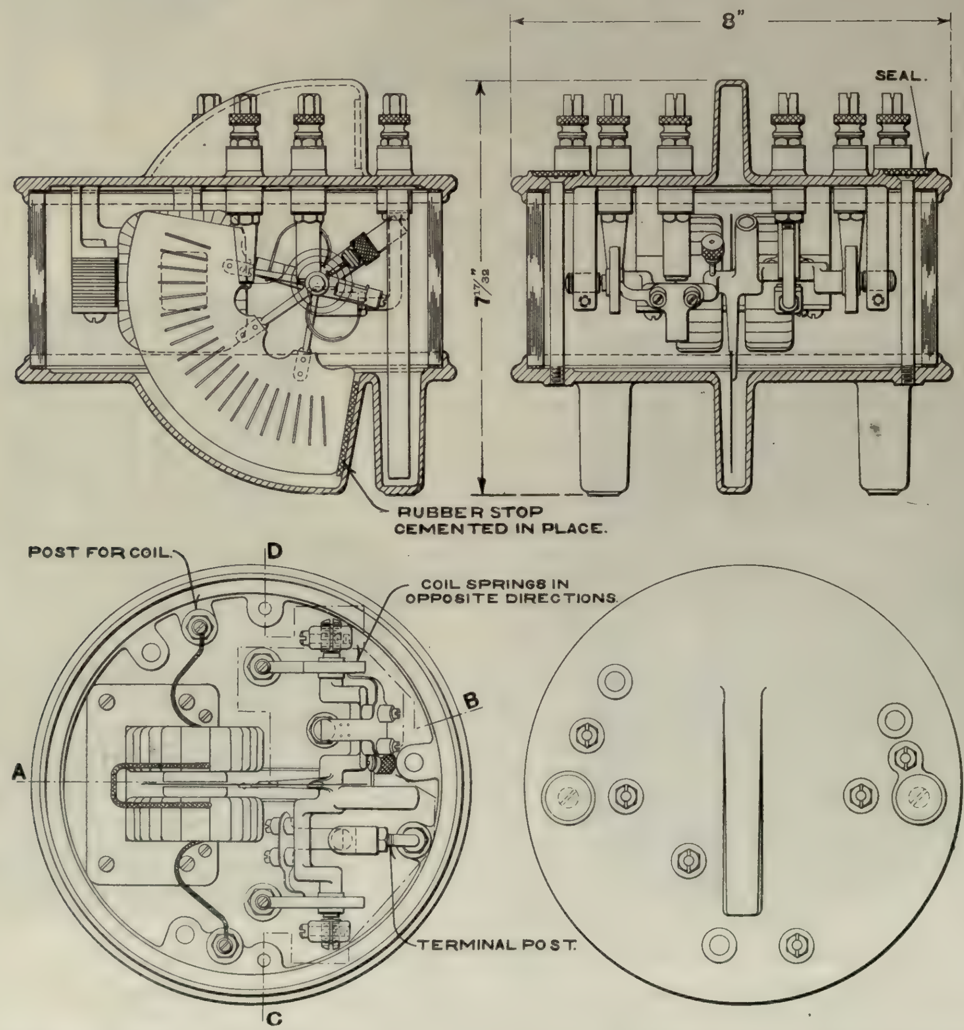


Fig. 680. Single Phase Alternating Current Track Relay.



Figs. 681-684. Details of Single Phase A. C. Track Relay. Union Switch & Signal Company.

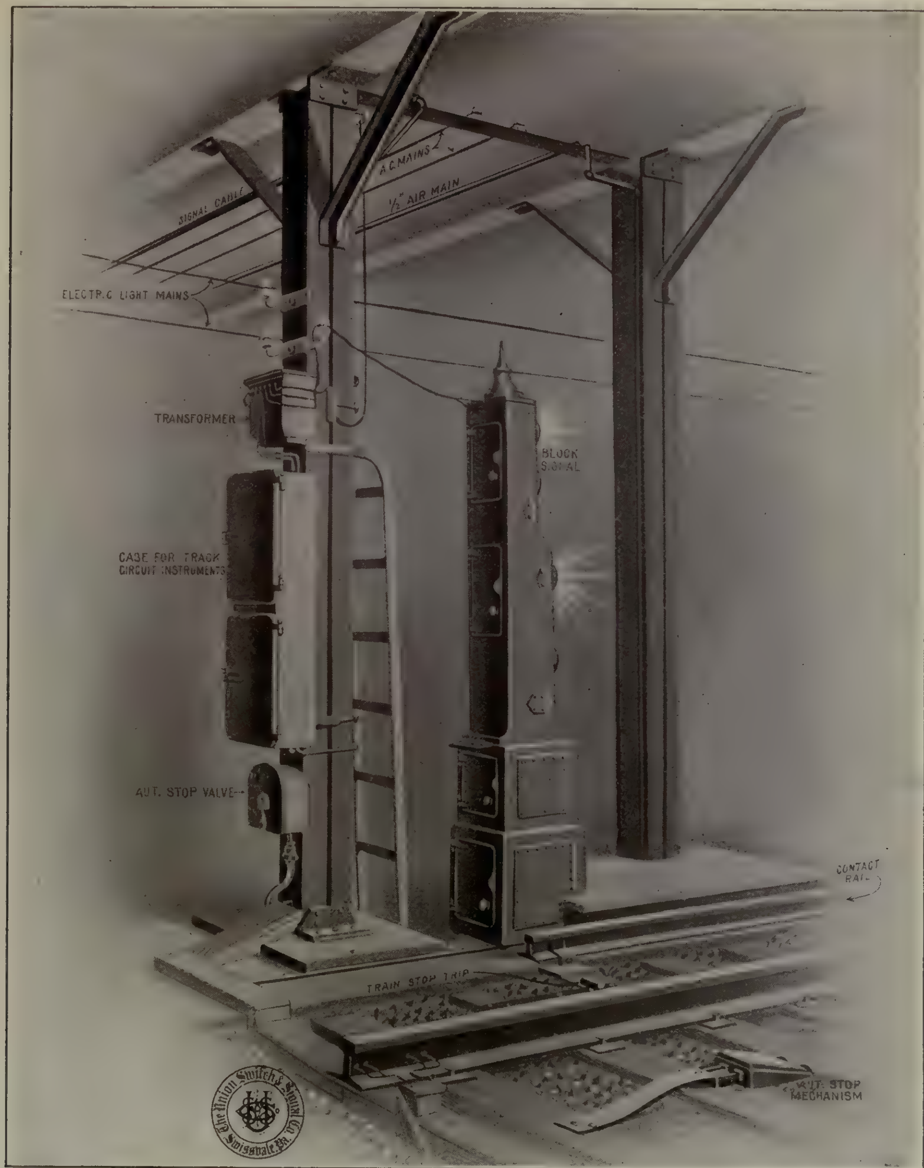
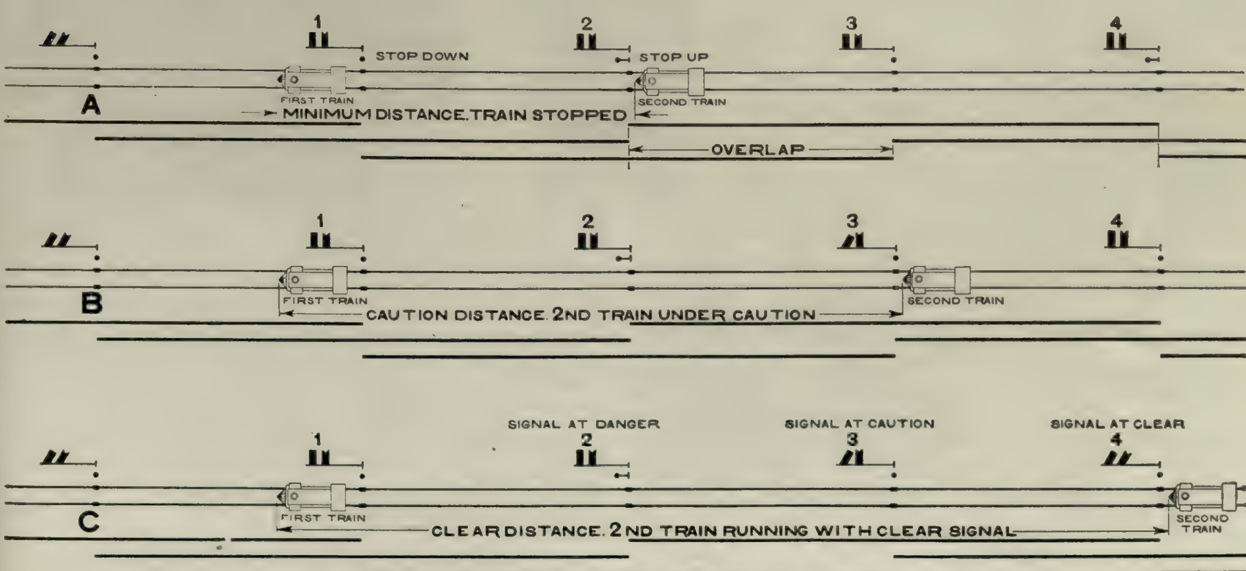


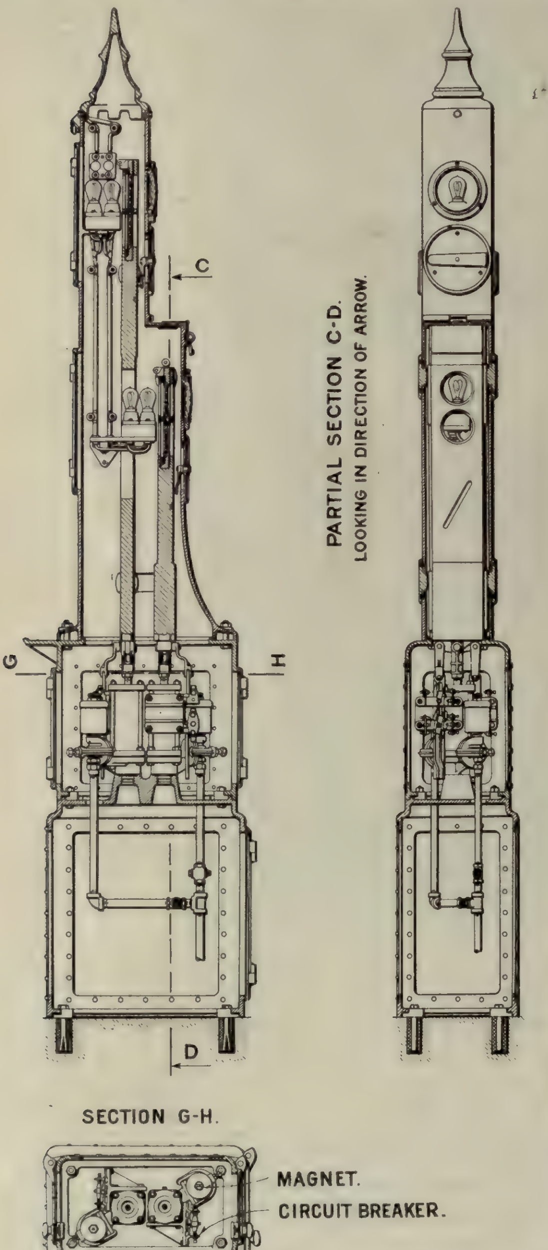
Fig. 685. Automatic Signal, Transformer, Instrument Case and Automatic Train Stop. Interborough Rapid Transit Company.



Figs. 686-688. Diagram of Overlapping Block Signal. Interborough Rapid Transit Company.

the home signal and the lower the distant. Suitable colored glasses are mounted in slides, which are operated by pneumatic cylinders. Home signals show a red light for the stop indication. Distant signals show a yellow light for the caution indication. All signals show a green light for the "proceed" or clear indication. A positive indication has been provided for, as an auxiliary to the color indications, in the form of a small arm immediately beneath the lenses. The small arm appears in a horizontal position when a stop or caution signal is displayed, and at an inclination of 60 degs. when clear, this being provided in addition to the color indications for use in case of failure of the lamps for the color indications. The exhibit the green color for the clear indication only when held in its upper position by the pneumatic cylinder; in this way any accident to the apparatus, cutting off the compressed air, will permit the slides to drop and indicate red or stop. The signals which are used on the exterior elevated portions of the system are of the semaphore type, although operated similarly to those in the subway sections and by a similar construction of mechanism.

Automatic train stops are provided and arranged so as to act at the second stop signal in the rear (see Figs. 675, and 686-688). That is to say, the train stop does not operate as soon as the signal, at which it is situated, goes to the



Figs. 689-690. Sectional View of Electro-Pneumatic Slide Signal Mechanism and Case. Interborough Rapid Transit Company.

Figs. 691-692. Double Electro-Pneumatic Slide Signal. Interborough Rapid Transit Company.

blade has [illegible] extending within the case and ending in a pin which [illegible] in an inclined groove in such a way as to turn the blade through an angle of 60 degs. as the slide passes from upper to lower position. The signal consists of two sections; the upper and rear portion contains the lenses and position indicator for the home signal. The front and lower portion of the case contains the distant signal mechanism. Each lens is constantly lighted by two 4 c. p. incandescent lamps at the rear, the two lamps being connected in parallel in order that one may be always lighted even if the other burns out. The pneumatic cylinders, which operate the heavy vertical sliding frames carrying the colored glass for the signal indications, are located in the base of the case. The slides stop position, but stays down until the train enters the overlap section, when it comes up in place to "trip" a train, should one run past the red signal. This arrangement is necessary in order to permit every car of a train to be fitted with the automatic brake valve, and at the same time not be "tripped" by the forward portion of the train entering the block. The signals are so placed that, at maximum speed, a train would be brought to a stop by the automatic application of the brakes before it could reach a preceding train.

This arrangement of apparatus, but without the overlap and train stops, was first used on the North Shore Railroad of California.

ELECTRIFIED LINES OF THE LONG ISLAND RAILROAD.

In the electrification of this road a third rail is used for delivery of the propulsion current and both of the running rails for its return. Direct current is used for propulsion and alternating current for signal track circuits, with inductive rail bonds. installed at the insulated joints separating different track sections, which give a free path for the propulsion current. Automatic signals are of the motor type (Fig. 538), with the exception of the two subways, where an electric light signal is used (Figs. 693-695). The lights in this signal are controlled by alternating-current line relays, which in turn are controlled by the track relays (Figs. 680-684).

On seven miles of double track, which has also been equipped with alternating-current track circuits for the signals, the inductive rail bond is not used, as this part of the road is not worked by electric traction. The alternating-current track circuit, nevertheless, was installed here for the operation of the existing system of automatic signals in this territory, on account of a third track on this division, which is electrified, and runs parallel with the two main tracks.

The length of the sections ranges from 1,000 to 1,200 ft., with the transformers (Fig. 676) connected at one end of the section, and from 1,300 ft. to 2,800 ft., with the transformers connected in intermediate positions.

The motor signals used are of the Union Switch & Signal Co.'s standard Style B type (Fig. 538). Current for the motors and the line relays is taken from two sets of storage batteries installed at every pair of signals and so arranged that one set is being charged while the other set is discharging. The charging current is taken from the third rail at 650 volts through a high resistance so proportioned that just the necessary current flows into the batteries. A 100-kilowatt transformer supplies the high-tension mains with the current at a potential of 2,200 volts and a frequency of 25 cycles.

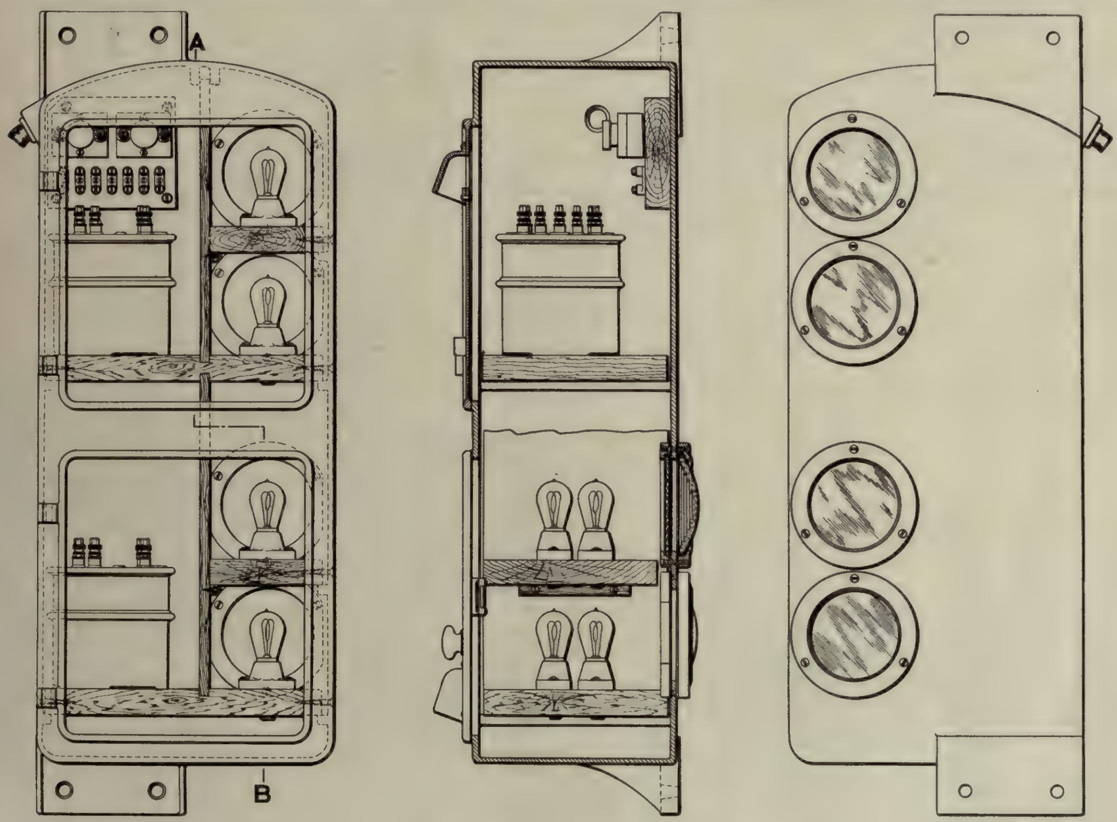
These mains are carried underground in a lead cable for about eight miles, and on the high-tension transmission pole line for the rest of the system. From the alternating-current main taps are brought into the primary transformers where the potential is reduced to 55 volts. This is in turn reduced in another set of transformers, called track transformers, to from two to six volts, as the conditions of the different track sections require. In the subways the lights in the signals and all line relays are also supplied from the 55-volt side of the primary transformers.

In the subway and on the elevated structure, full block overlaps are used.

WEST JERSEY & SEASHORE RAILROAD.

The automatic electro-pneumatic signals are controlled by alternating-current track circuits flowing through the running rails, which also convey the return direct current of the propulsion system; and the air compressors are run by electric motors supplied with current from the third rail.

Fig. 697 is a diagram of a typical track circuit. In consequence of the difficulty of conveying alternating current through the rails of the track under the existing conditions, the track circuit is conveyed from the transformer to the rails in the middle of the block section, as shown. Thus, in a



Back View, Cover Removed. Side View, Section A-B. Front View.

Figs. 693-695. Double Electric Light Subway Signals. Long Island Railroad.

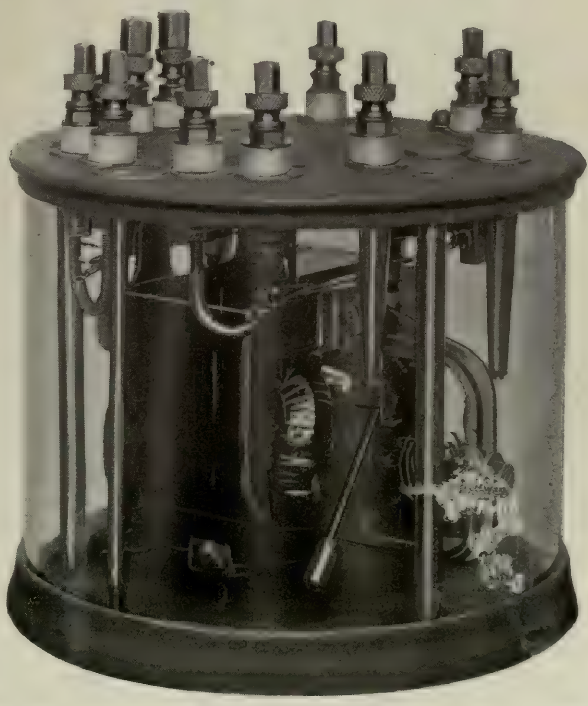


Fig. 696. Alternating Current Relay, Wire Wound Armature. West Jersey & Seashore Railroad.

signal section 4,000 ft. long the current has to pass through only 2,000 ft. of track. The track relay (Fig. 696) is controlled not only by the track circuit, but also by the current through the line wires, as shown in the lower part of the drawing.

On the West Jersey & Seashore, the propulsion current conditions were as follows: Maximum capacity of each sub-station in amperes, 3,500 to 7,000, ultimate; normal average output of each sub-station in amperes, 1,500; number of amperes to start trains on a level, 500 to 1,200 amperes per car; number of cars per train, six.

The inductive bonds and their connections which have been put in to meet these conditions introduce in each rail a resistance per block equivalent to only about 40 ft. of 100-lb. rail, so that in the 4,000-ft. blocks the increase in the resistance of that part of the propulsion return system formed by the rails is only one per cent. The relays are of the motor type, the armature and the field both having coils which are energized when the current flows. The field is supplied by the 25-cycle current taken from the rails at the entering end of the block. The armature is supplied by the current from the leaving end of the block and the current, which is taken from the rails at the leaving end, is stepped up for transmission by a six-watt transformer. The transformers are not injuriously affected by being short-circuited by trains standing opposite them. Their primaries are fed by the 1,100-volt, 25-cycle signal mains running from the sub-stations. At each sub-station there is a switchboard for handling the signaling current, which is stepped down to the signal line voltage from one leg of the propulsion mains. The switchboard is supplied with indicating instruments for showing the voltage of the signal mains and of the current going in either direction. Recording wattmeters are provided to determine how much power is used by the track circuits. The arrangement of oil switches is such that the signal mains can be disconnected on either side of the sub-station or made continuous and disconnected from the sub-station.

Oil line switches are fixed in the signal mains midway between the sub-stations, so that in case of line trouble a maintainer can, without risk to himself, open the line and limit the trouble to the territory in which it exists.

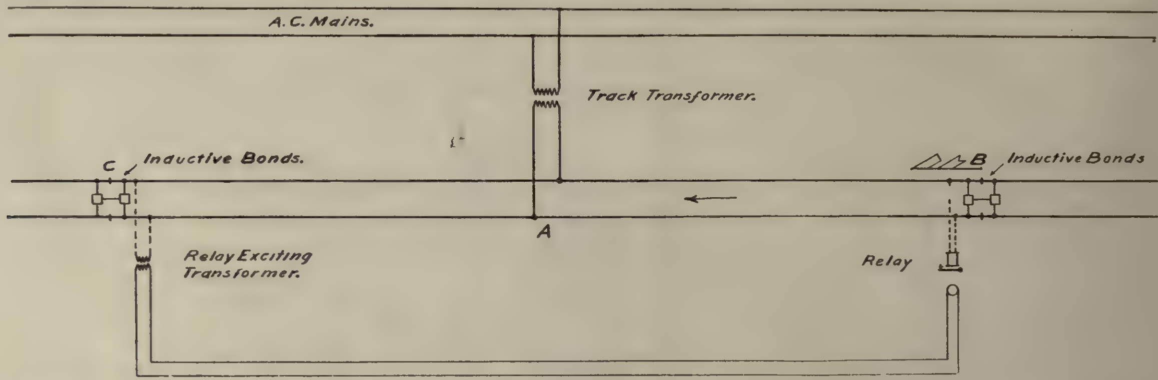


Fig. 697. Diagram of Transformer and Track Circuit Connections. West Jersey & Seashore Railroad.

NEW YORK, NEW HAVEN & HARTFORD.

Fig. 699 shows the type of automatic signals installed by the Union Switch & Signal Co. on a section of the New York, New Haven & Hartford Railroad. This section is used both for steam and electric traction, the electric cars taking direct current from an overhead trolley wire. Through the entire length of the signaled section there is a 10,000-volt, three-phase, 60-cycle commercial line giving a reliable 24-hour service. From this supply current is procured for the signal system, the connection being made through step-down transformers. The transformers are connected to one phase of the high potential line, stepping the current down from 10,000 volts to 2,200 volts and connecting through oil switches to the signal transmission lines which extend the entire length of the signal system. From this 2,200-volt, 60-cycle line, current is obtained through transformers for the various signal requirements. The automatic signals have home and distant arms, pivoted near the center and mounted upon the same post. The eastbound and the westbound signals are placed nearly opposite each other, but are staggered sufficiently to avoid putting a signal where a trolley pole will hide it from the engineman. The blade grip castings are designed to permit the arm to extend to the left of the post for the reason that the trolley poles would obstruct the view of the signal if it extended only to the right.

The motor signals have double-case bases and rest on concrete foundations. The upper case contains the signal mechanism, which is operated by a 110-volt single-phase induction motor. The motor has sufficient torque at starting to start under load from any point in the arc through which the signal travels. The time required to clear both the home and the distant arms is five seconds. The lower case contains track relays, line relays, controlling switches, fuses and lightning arresters. Duplicate two-candle-power incandescent electric lights are used in the lanterns. Oil founts are also provided.

At each signal there is a transformer stepping down from the

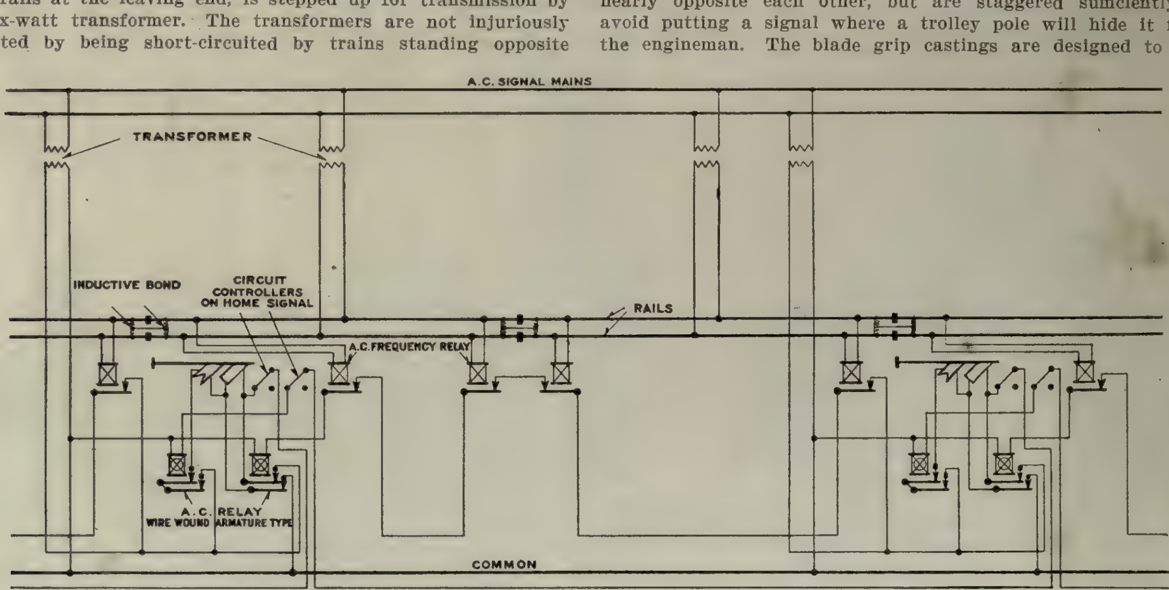


Fig. 698. Arrangement of Control Circuits for Normal Clear Alternating Current Automatic Block Signals. New York, New Haven & Hartford.

2,200-volt line to 110 volts to supply current for the local signals and the control circuits for the next signals in the rear. The signal control line extends the entire length of the block section, taking energy at the outgoing end and looping through the track relays and switch instruments.

The track circuit equipment installed is designed to be used with a propulsion current either direct or alternating; either 550-volt direct or 11,000-volt, 25-cycle, single-phase alternating. The electric railway company required that the tracks be cross bonded at least every 3,000 ft., thus making necessary a cut section in each block. Energy is supplied to the tracks by a transformer situated in the middle of a track circuit section. The track circuit has a relay at each end. These are "frequency" relays, that is to say, relays which respond only to alternating currents of a given frequency. These control the signal circuits. At each end of the track circuit there is also an inductance bond, the terminals of which are connected to the rails, and the center of which is connected to the center of the bond of the next track circuit, thus forming a metallic connection around the insulated rail joints for the return propulsion current. This center connection may also be used for cross-bond connection to the other track.

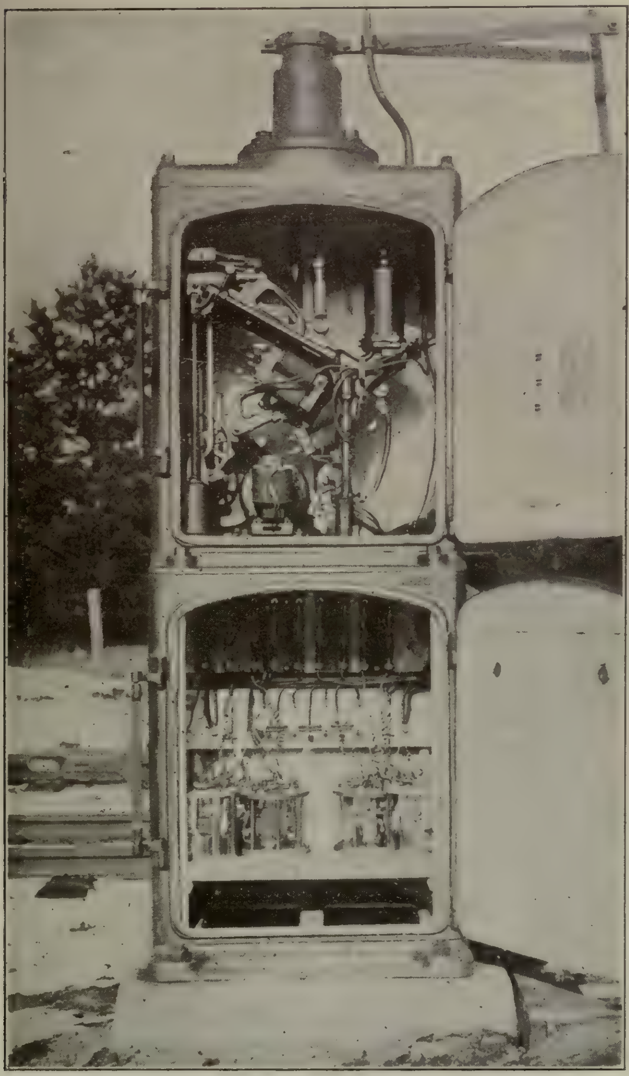


Fig. 699. Alternating Current Signal Mechanism and Relay Case. New York, New Haven & Hartford.

The inductance bonds were designed to carry the heavy current necessary with direct-current propulsion and also were balanced to offer the least possible impedance to an alternating propulsion current. In fact, if the external track return is perfectly balanced, the only impedance of the bonds may be said to be ohmic. The frequency relays are of the vane type and are immune to a direct current or to alternating current of 25 cycles, having been designed to operate at 60 cycles. The unbalancing of the track, therefore, even if sufficient to throw a heavy current through the frequency relays, would not result in a false clear signal indication. This system will, of course, not be affected by any foreign trolley current. To connect up an inductance bond to a track with "broken" or "staggered" joints, it is necessary either to cut one rail of the track so as to have the insulated joint near the bond, or to provide a conductor from the bond to connect with the track beyond the insulated joint. In this case use is made of a piece of old rail about 15 ft. long. The piece of steel rail is better than copper because it costs less and is not liable to be stolen; and besides this, if alternating current is used for propulsion, the iron serves to restore the balance of the inductance of the two lines of rails, which with one side 15 ft. shorter than the other, would be unbalanced.

Fig. 698 shows a diagram of typical circuits used in this installation.

BOSTON ELEVATED RAILROAD.

Figs. 700-709 illustrate the automatic block signal circuits and apparatus used on the rapid transit lines of the Boston Elevated Railroad. On this road the propulsion system uses direct current delivered by a third rail and returning by one of the running rails which is grounded to the elevated structure, the negative terminals of the propulsion generators being connected to the grounded rail. The other running rail, designated as the "block rail" in Fig. 701, is given up exclusively to signaling purposes. It is divided into sections by insulated joints, each section constituting one side of a "single rail" track circuit, the grounded rail being a common conductor for both signal and propulsion current.

This being the first installation where it was attempted to use signal track circuits together with propulsion current return on the running rails, it may be well to consider the feature known as "drop in potential" along the common rail, caused by the presence of the propulsion current.

Fig. 704 illustrates how the presence of two trains might cause a difference of potential across the relay terminals. When current is flowing in any conductor there is always a difference of potential between any two points on that conductor due to its resistance. V represents a voltmeter so connected as to measure the potential due to the flow of return propulsion current over the continuous rail. With one train at the leaving end of the block and another approaching, the relay has the same potential across its terminals as that measured by the voltmeter, for wire *a* connects on side at the same point as the positive lead of the meter, and wire *b*, the insulated rail, and the wheels and axles of the train at the right connect the other side to the same point as the negative lead of the meter. Whether or not an ordinary type of relay will close its contacts under these conditions depends on whether or not the voltage at which it is adjusted to operate is greater than the drop of potential caused by the return of power current over the length of rail measured by the length of the block.

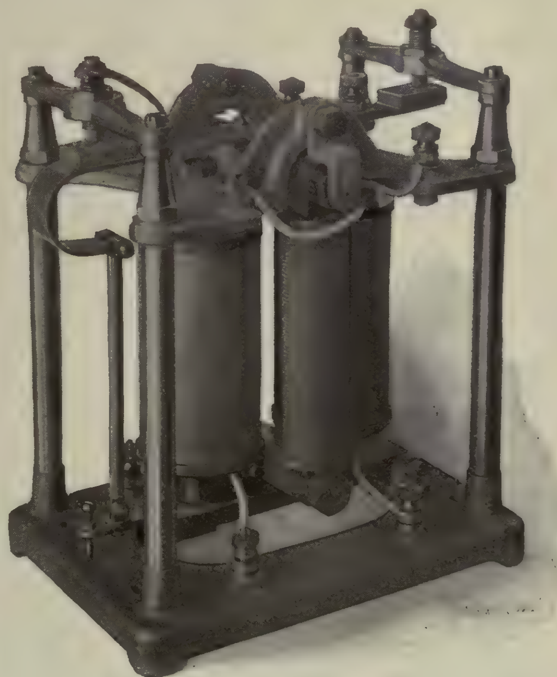


Fig. 700. Polarized Track Relay. Boston Elevated Railroad.

However, in the case of the Boston Elevated Railroad, the blocks are short and the common return rail is grounded at close intervals to the structure, which has a copper equivalent of 14,000,000 circular mils. These conditions make it permissible to use a relay whose voltage adjustment provides against any "return drop" which may occur.

The signals are of the electro-pneumatic type made by the the mechanism case of a signal, and also the adjustable resistance tubes for the track circuit in the rear. The electro-pneumatic valve and cylinder which operates the signal are placed on the back side of the partition, as shown in Fig. 701.

The relay (Fig. 700) is operated by direct current, requiring a potential of five volts at its terminals to "pick up," and is polarized; its magnet is wound to 50 ohms resistance. The

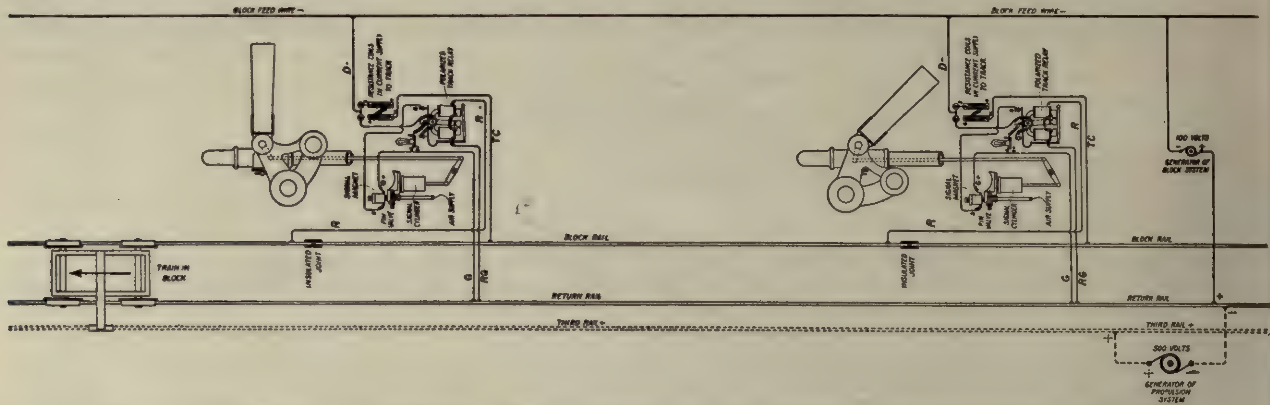
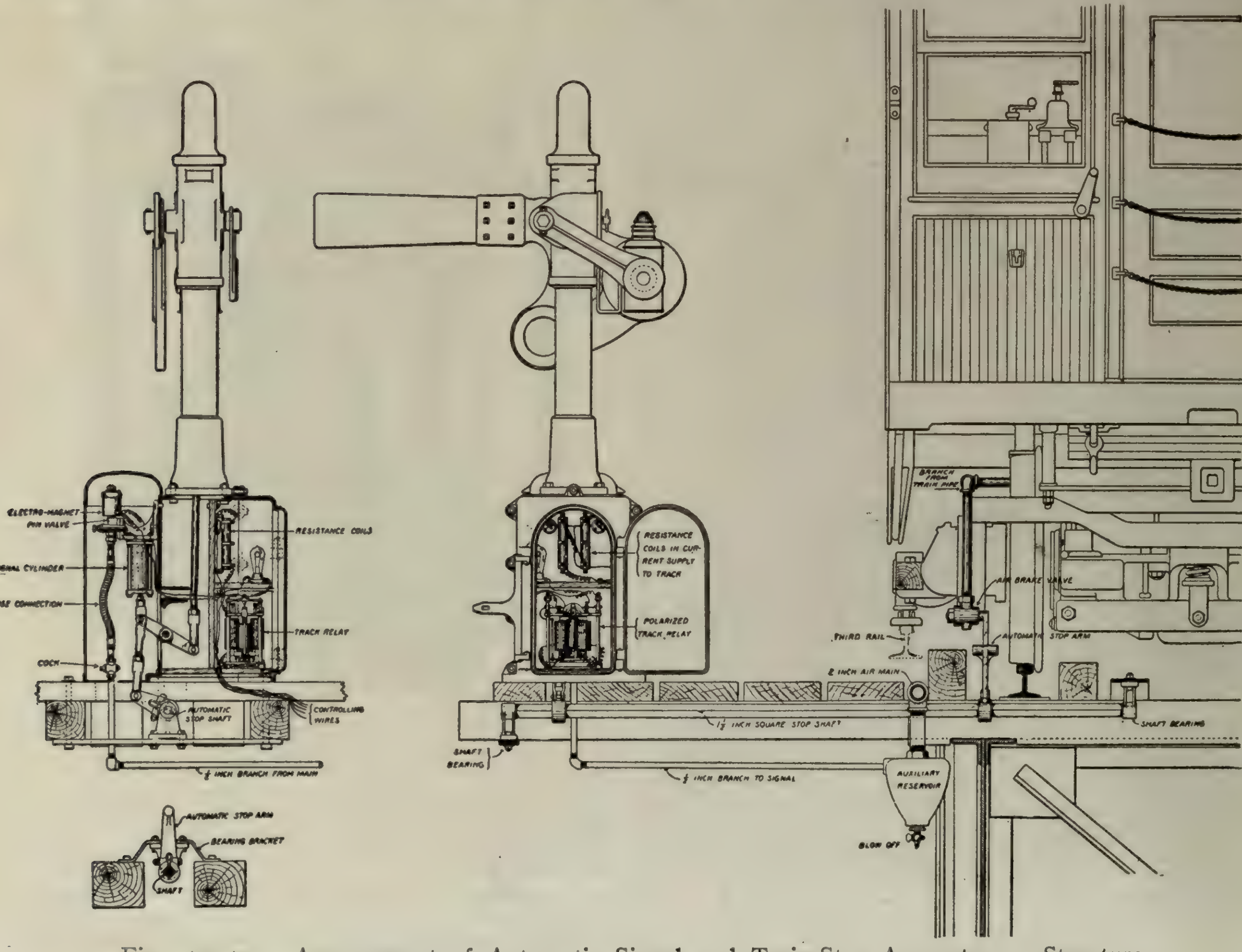


Fig. 701. Diagram of Automatic Signal Circuits and Apparatus. Boston Elevated Railroad.

Union Switch & Signal Co., and operate "normally clear." Current is supplied to the signal system from 100-volt generators by the main "block feed wire" (Fig. 701), with the grounded rail of the tracks as a return. It is to be noted that the *negative* terminals of the signal generators are connected to the feed wire and the *positive* terminals to the horizontal armature at the base is raised by the large 50-ohm magnet, when energized, irrespective of the direction of the current. The link extending upward connects this horizontal armature to a phosphor-bronze contact plate carrying two heavy carbon blocks, one at each end, which lie under contact points of the same substance mounted above them and properly



Figs. 702-703. Arrangement of Automatic Signal and Train-Stop Apparatus on Structure. Boston Elevated Railroad.

grounded rail. An adjustable resistance is introduced between the feed wire and the block rail of each track circuit, which limits the flow of current while the block is occupied and prevents the shunting of one track circuit from affecting any of the others. The track relay is one of the notable features of this installation, being quite a departure from ordinary practice in signal work. Figs. 705-706 show this relay mounted in insulated. The contact plate is rigidly secured to the upper pole-piece of a pair of smaller magnets mounted transversely to the one first mentioned and pivoted on trunnions formed upon the ends of the upper pole-piece. The lower ends of these swinging magnets are joined by the lower pole-piece, which hangs between the extended cores of the larger magnet and is attracted by one or the other, according to its polarity. The

swinging magnets are wound to produce like poles at the same ends, hence the two pole-pieces joining them actually constitute the poles of one double magnet. The coils of the 50-ohm magnet are wound in the usual manner and included in the track circuit, being energized (when the block is unoccupied) by current from the signal generator. The right-hand contact is operated by motion of the swinging magnets. left. But as soon as the left-hand contact is closed, current passes from the grounded rail through the resistance lamp and the swinging coils to the feed wire. This circuit, energizing these magnets, causes their lower pole-piece to swing to the right, bending the contact plate and closing the right-hand contact; this latter contact completes the circuit through the signal control magnet and clears the signal. It will be seen

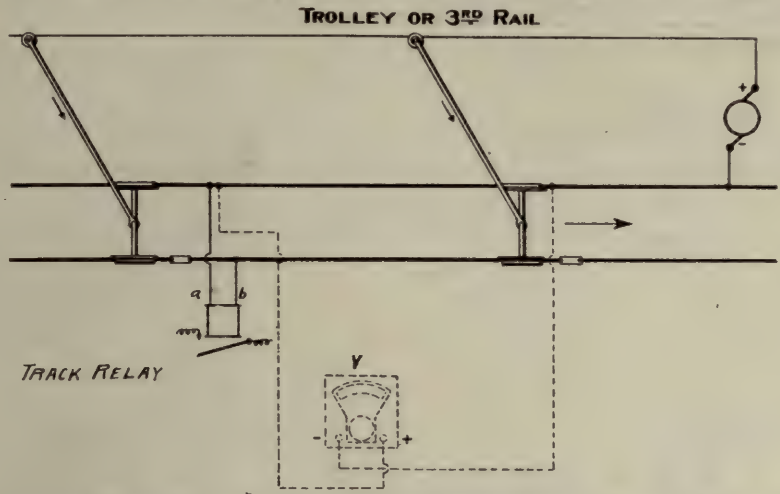


Fig. 704. Diagram Showing Potential at Terminals of a Track Relay. Due to Return Propulsion Current. (Reproduced from the Proceedings of the American Institute of Electrical Engineers. Copyrighted 1907.)

Suppose the relay to be de-energized by the presence of a train in the block, the sequence of operation in closing the relay contacts is as follows: As soon as the train passes out of the block current flows from the positive terminal of the signal generator along the grounded rail through the 50-ohm that there is a mechanical counter effect of the swinging magnet upon the work performed by the neutral armature which will cause the latter to drop in response to a very slight reduction in current.

When a train again enters the block it shunts the 50-ohm

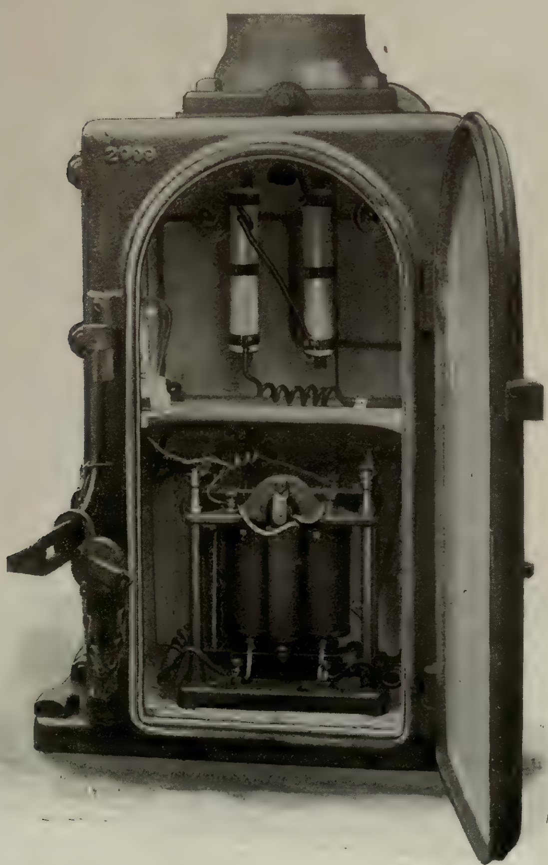


Fig. 705. Relay, Resistance Tubes and Lamp in Signal Case. Boston Elevated Railroad.

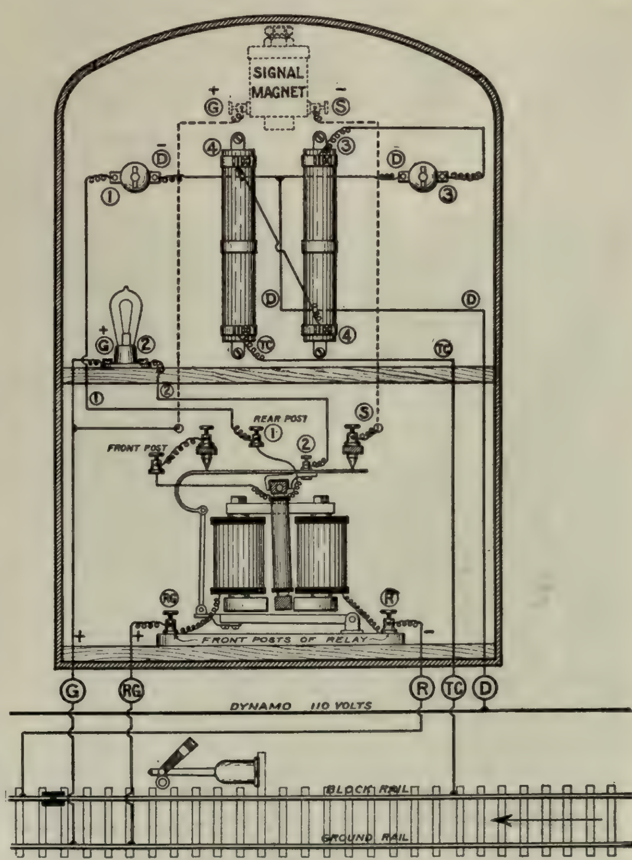


Fig. 706. Diagram of Signal Control Apparatus. Boston Elevated Railroad.

coil of the relay at the signal on the right (Fig. 701) along the block rail, through the resistance tube at the signal on the left and back over the main feed wire to the negative terminal of the generator. This picks up the armature at the base of the relay, closes the left-hand contact, and tends mechanically to move the lower pole of the swinging magnet to the coils causing the lower armature to drop and open both contacts. If now, while the train is in the block, the wheels should make poor contact on the grounded rail (on account of the presence of sand or ice, or for any other reason), propulsion current might flow from the wheels to the block rail and through the relay to the grounded rail. This would pick

up the neutral armature, but in this case the polarity of the current and consequently that of the magnet is now reversed, and as soon as the left-hand contact closes permitting current to pass through the swinging coils, they are held over to the left, preventing the right-hand contact from closing and

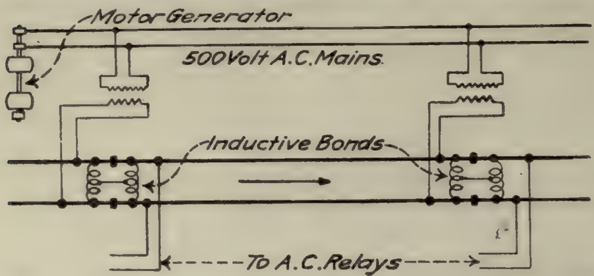


Fig. 707. Diagram of Transformer and Single Phase Track Relay Connections, East Boston Tunnel. Both Running Rails Used for Propulsion Current Return.

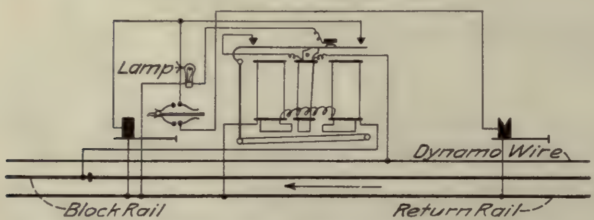


Fig. 708. Circuits for Control of Distant Signal. Boston Elevated Railroad.

keeping the signal in the stop position. The swinging coil being in series with the signal magnet, any interruption in the circuit which might tend to depolarize the relay would also result in the signal going to the stop position.

Fig. 708 shows the circuit used for control of a distant signal.

Figs. 702-703 show how the signal is set in relation to the track on the elevated structure, and also illustrate one method of connecting the automatic train stop, which is a feature of

Fig. 709. Tunnel Signal and Automatic Train Stop. Boston Elevated Railroad.

this installation. Fig. 709 gives a view of the tunnel signal and train-stop used in the subway. This signal has no blade, the light being its only indication. The train-stop is operated by a separate cylinder instead of by a rocker-shaft as on the structure.

INTERBOROUGH RAPID TRANSIT COMPANY'S ELEVATED LINES.

The Interborough Rapid Transit Co. has in service on the elevated lines semaphore block signals, operated by solenoids energized by current taken from the third rail. The current for the track circuit is also obtained from the third rail. The apparatus and circuits for a typical block section are shown diagrammatically in Fig. 712. Only one of the track rails is insulated for the block section, which varies in length for the different locations where the signals are used. At the outgoing end of the block, the third rail is connected through a fuse to a resistance plate having two taps at the upper end, one of which is connected to the insulated track

Fig. 710. Solenoid Semaphore. Interborough Rapid Transit Company.

rail and the other to the opposite or common track rail, which is grounded for the return power circuit. The resistance is adjusted to give a difference of potential between the two-track rails of 10 volts. At the entering end of the block, the two-track rails are connected together through a two-point track relay, which is wound to pick up at three volts. The normal difference of potential of 10 volts is sufficient to care for the widest variations in voltage of the third rail current passing through the resistance plate.

At the signal, a tap from the third rail connects to a bus bar on which are three snap switches, one in the solenoid relay circuit, one in the main signal solenoid circuit, and one in the signal lamp circuit. When no train is in the block, the track relay is energized and its two contacts are closed. Current from the third rail passes through switch 1, resistance, track relay, armature, solenoid relay coil and thence to common rail or ground. Current also flows through switch 2, armature of solenoid relay and resistance of 3,000 ohms to solenoid coil and thence to ground, holding the signal in the proceed position.

When a train enters the block, the track relay opens, releasing the spring-actuated quick-break solenoid relay, whose armature controls 600 volts. This breaks the solenoid circuit and permits the signal arm to go to stop by gravity. An oil dash pot is provided to cushion the shock of the moving arm. When the train passes out of the block the track relay picks up, causing the solenoid relay in turn to pick up. Current

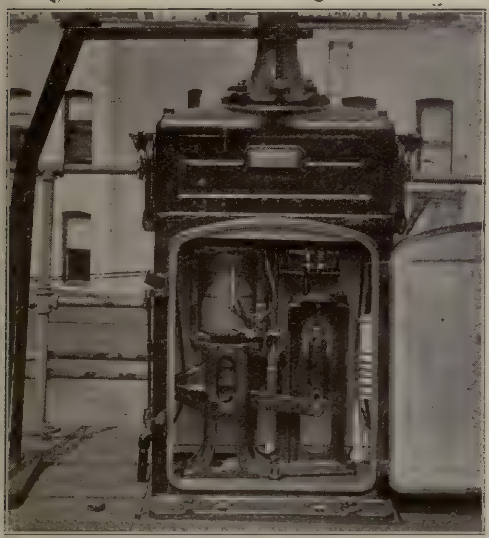


Fig. 711. View of Mechanism of Solenoid Semaphore Signal. Interborough Rapid Transit Company.

above the dash pot. In the upper part of the case are the two relays and the snap switches. Good results have been obtained from the special track relays employed, which are made with carbon points on the springs bearing on German silver pedestals. The quick-break solenoid relays, controlling 600 volts, have also proved satisfactory. Pittsburgh insulated joints of the latest pattern are used in the track and are said to be standing up well under the heavy traffic which passes over them. The signals and relays were made by the Union Switch & Signal Co.

SYKES ELECTRIC TUNNEL SIGNAL.

Fig. 713 illustrates a simple form of signal electrically operated and electrically lighted as used in a Sykes installation on a double-track tunnel line on the Waterloo & City Electrical Railway. In the figures, A A are two coils of an

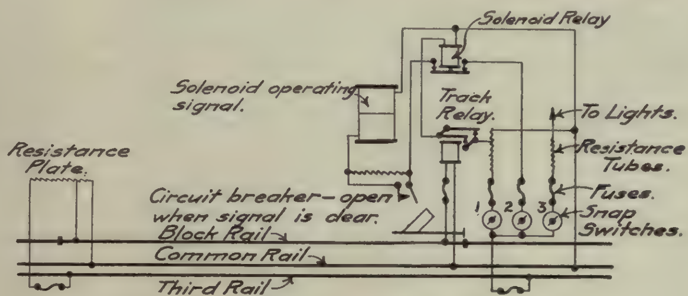
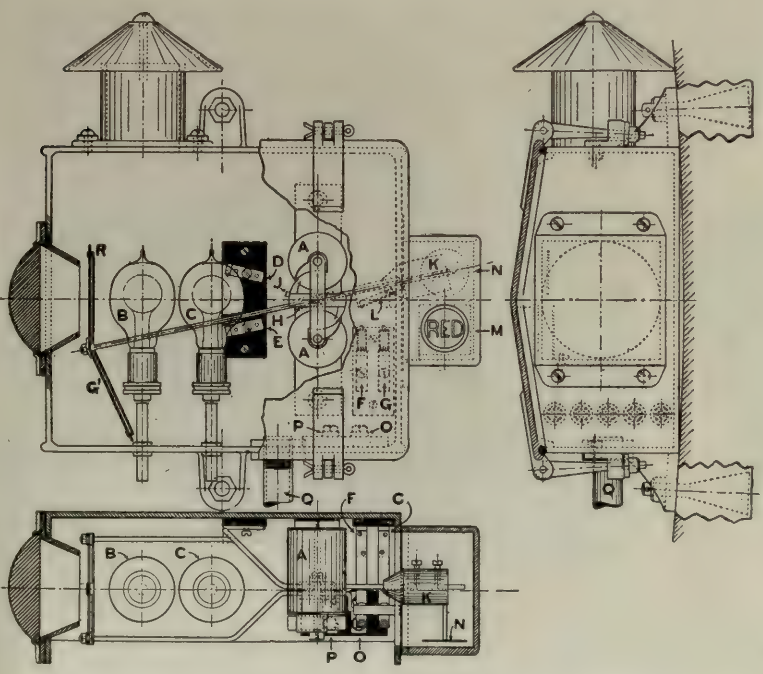


Fig. 712. Circuit Diagram for Solenoid. Interborough Rapid Transit Company, Elevated Lines.

from the third rail (at 600 volts potential) then flows through the solenoid relay armature and the circuit breaker which is closed. This gives a powerful circuit in the signal solenoid to move the signal down, but as soon as the arm reaches the proceed position the circuit breaker opens, cutting in the high

electro-magnet with a Z-shaped rotating armature, to which is attached a frame extending around and in front of two white electric lights and supporting a red and a green glass between the lights and the signal lens; the red being above the green. When the magnets are de-energized by a train in the



Names of Parts of Sykes Tunnel Signal; Fig. 713.

A *Operating Magnet*
B *Electric Light*
C *Electric Light*
D *Upper Stop for Frame*
E *Lower Stop for Frame*
F *Fuse*
G *Fuse*
G[1] *Green Glass*
H *Armature*
J *Screw*
K *Counterweight*
L *Contact Arm*
M *Opening for Indicator*
N *Indicator Disk*
O *Binding Post*
P *Binding Post*
Q *Wire Conduit*
R *Red Glass*

Fig. 713. Sykes Electric Tunnel Signal. Waterloo & City Electric Railway, London, England.

resistance and allowing only a small current, enough to hold the signal in the clear position, to flow through the solenoid.

Fig. 711 shows the signal mechanism enclosed in the iron case at the foot of the post. The solenoid plunger is connected to a pivoted lever to which the dash pot is fastened at its outer end. The up-and-down rod is fastened about midway between the solenoid plunger and the dash pot. Resistance tubes are mounted on one side of the case and the circuit breaker attached to the up-and-down rod can be seen just

block ahead or for any other reason, the frame carrying the glasses drops by gravity, bringing the red glass in front of the lights and displaying a stop indication. When the track circuit is unoccupied and the track relay picked up, the magnets A A are energized and the armature rotates, raising the frame so as to bring the green glass in front of the lamps and display a clear signal. K is a counterweight carrying an indicator repeating the position of the signal at the side of the case.

SELECTIVE SIGNALING FOR STEAM AND ELECTRIC ROADS

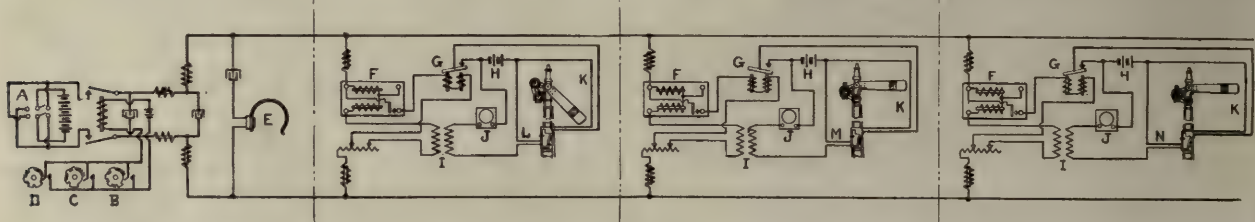
DISPATCHER CONTROLLED SELECTIVE TRAIN ORDER SYSTEM.

The United States Electric Co.'s selective train-order system is primarily intended for single-track lines. It is a combination of two pieces of apparatus, the electric slot semaphore and the electric selector and answer-back. The signal blade is held in the safety or clear position by a magnet in the electric slot, which is normally energized by the local battery. When the dispatcher desires to throw any particular signal to the danger or stop position he turns the automatic calling key which corresponds to that signal station, the same as in train-dispatching calling. When the contact of the selector F (Fig. 714) closes, it completes the circuit of the semaphore relay G, which then operates the slot, thus causing the semaphore blade to go to the stop position. In the conclusion of this movement, a bracket carried by a sleeve on the descending rod (Fig. 715) depresses a plunger and allows the answer-back mechanism, shown in the lower right corner, to operate. This mechanism is driven by a coiled spring and repeats to the dispatcher, by induction over the telephone wire, the combination number of the signal moved, thus assuring him that it is set at danger. As soon as the blade has finished its movement and assumed the danger position, it is mechanically locked. This lock holds the signal against manual resetting by pulling down the blade. After orders have been given by telephone to the train crew and properly verified, the dispatcher gives permission for the restoring of the signal by reversing the calling battery by means of switch A (Fig. 714), and sending again the station call by his individual key. This again closes the selector contact F and closes that of semaphore relay G, permitting the signal to be restored to the clear position. Other reference letters in Fig. 714 are: B, C, and D calling keys; E, dispatcher's telephone receiver; H, local battery; I, induction coil; J, buzzer; K, wires to semaphore magnet; L. M. N. wires to answer-back. In the operation of restoring the signal, the mechanical locking-lever is unlocked by a stud carried by the descending slot latch, allowing the signal rod to be moved to reset the blade.

The system is operated on a closed circuit and is so arranged that any failure of the current supply controlling the signal will set the signal at the stop position. A 6-cell 10-volt local battery of the closed-circuit type is required at each signal. The signal may be arranged with double lenses to show the light in both directions, or separate signals for movements in opposite directions may be mounted on a single mast. The selective signaling apparatus, when connected direct to the ordinary train dispatcher's telephone or telegraph line, does not interfere with the service at other stations where semaphore signals are not installed.

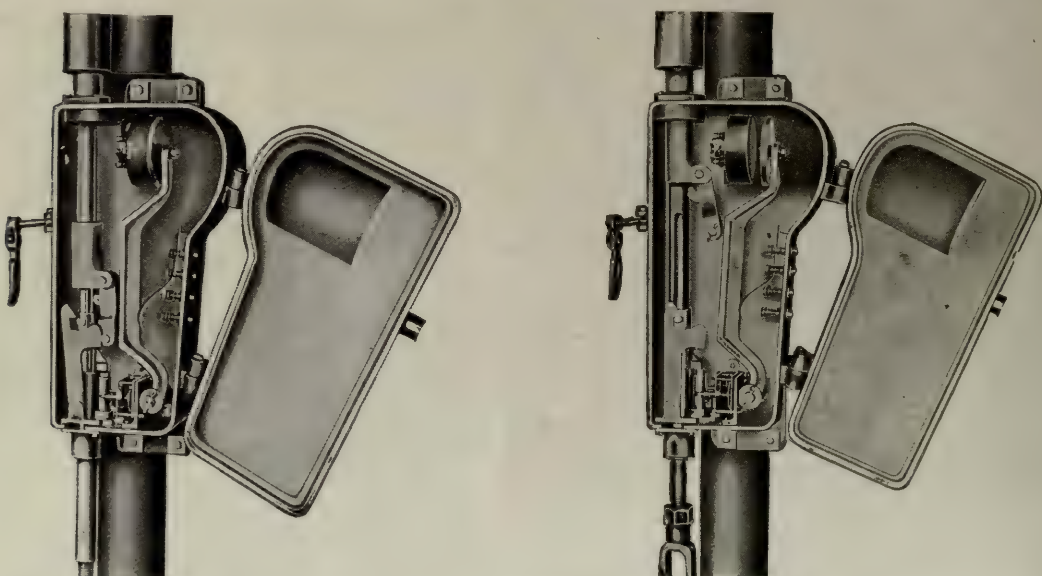
UNITED STATES ELECTRIC SELECTIVE SIGNALING SYSTEM.

The Gill selector consists essentially of a ratchet or combination wheel, an electro-magnet, the armature of which is arranged to step the wheel forward, a retaining pawl to retain the teeth stepped and a mechanical time element, the function of which is to permit the retaining pawl to assume either one of two positions, according to the length of the current impulse. The time element consists of a metal wheel carried on a shaft of small diameter, so arranged that it can roll on its axis or shaft, down an inclined rod. When the stepping arm is in its upper position the wheel is prevented from descending, but when the arm moves to its lower position, due to the current, the wheel rolls and will reach its lower limiting position provided the current impulse is of long enough duration. If, however, the impulse is short, the stepping arm will return to its upper position due to the armature action and prevent the wheel from descending the full distance. The time wheel, through a system of levers, is so arranged that it permits the retaining pawl to fall in the teeth of the combination wheel to one-half their depth if it is in the upper position and to the full depth if it is in the lower position. Some of these teeth have a diagonal slot sawed through their lower half, while others have the top of the tooth diagonally cut away. The retaining pawl has a horizontal movement as well as a vertical one. Fastened to the pawl is a knife-edge piece which falls behind the teeth and holds the wheel from returning to normal when the stepping pawl is in its upper position, preparatory to making another step. If, however, that part of the tooth against which the knife-edge rests is diagonally cut away, the



Semaphore at Clear Position, Latched. Semaphore at Stop Position, Locked. Semaphore at Stop Position, Unlocked.

Fig. 714. Diagram of United States Electric Company's Selective Train Order Signal Circuit.



Figs. 715. United States Electric Company's Train Order Semaphore Box.

pawl will be pushed to one side and the wheel will return to its normal position. In order for the retaining pawl to hold each tooth stepped of a given selector, its position with relation to the teeth must be such that at no time does the knife-edge rest against a part of a tooth face which has been diagonally cut away. This condition is brought about only in the case of a selector which is being operated by the proper combination of impulses, and this selector is the only one in the circuit which will close its contact and signal the station. All other selectors in the circuit fail to reach the contact position, because at some point or points the pawl has slipped out, allowing the combination wheel to return to its initial position.

The Gill selector for telephone service is wound to a resistance of 4,500 ohms so that it can be bridged directly across the telephone circuit and operated without the use of relays on from eight to 25 milli-amperes without change in adjustment.

The sending of the proper combination of current impulses is accomplished by automatic calling keys at the dispatcher's office. A key consists of a spring-driven train of gears operating a circuit breaker, the specially cut code wheel sending out over the line a certain combination of impulses which brings to the contact position only that selector at the station desired to be called and which alone responds to the combination just made. No adjustment of keys is necessary. All the keys for a circuit are assembled on the dispatcher's desk in a convenient cabinet, as shown in Fig. 717. The dispatcher is assured of the call being received at the station, as he receives an answer back signal from the station bell itself. The Gill bridged telephone selector may be used with a bell rung by a local battery or by the main line battery, this latter being

Fig. 716. Dispatcher's Desk Cabinet.

Fig. 718. Local Battery Bell Box Outfit—Uncovered.

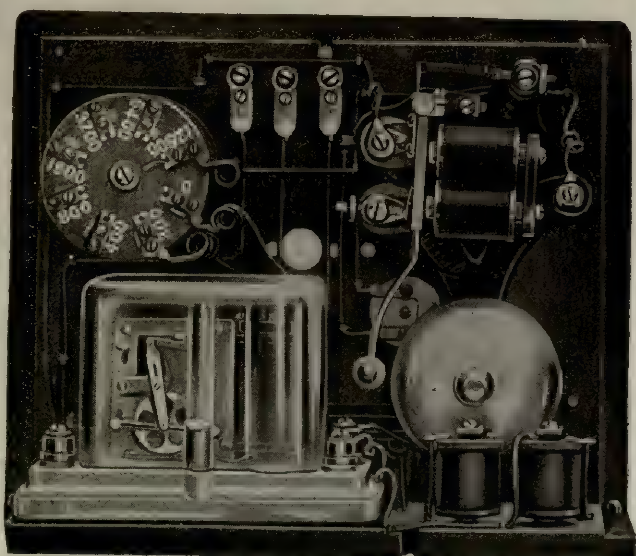


Fig. 717. Main Line Bell Outfit—Uncovered.

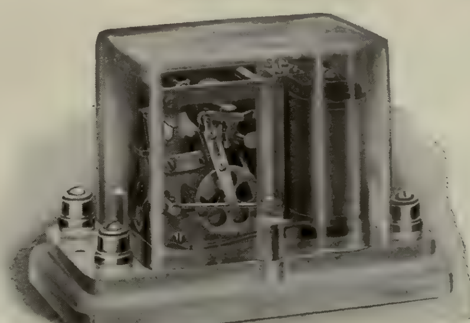


Fig. 719. Gill Selector. United States Electric Company.

Figs. 716-719. Gill Selector Train Dispatching Apparatus. United States Electric Company.

or local batteries at the stations, and without causing a loss in telephone transmission. It is operated by direct current from dry cells, storage cells, telegraph dynamos or direct lighting current. The Gill telephone selector will operate on from eight to 25 milli-amperes of current, giving ample margin of operation to take care of variations in battery and line. The Gill telegraph selector is arranged to operate directly in series with the line or from a sounder battery. It will operate on from 200 to 600 milli-amperes without change in its adjustment. It is also wound to 4,500 ohms for operation on a 40 or 110 volt local circuit. The 4,500-ohm type will operate the same battery as that sending the calling impulses. If the local battery is used, two dry cells are provided at each outfit and the main signaling battery is not on the line during the ringing period. The circuit of the local battery bell bridged telephone is shown in Fig. 720. All the apparatus shown at the way station is assembled in a box. When both the selector and bell are supplied with current from the main signaling battery, the station apparatus is reduced to a minimum. Although calling by the main line bell battery causes a slightly larger current flow from the main signaling battery every time a station is called, the increased current is not very great,

as high resistance bells of 1,800 ohms are used, requiring eight to 12 mils to operate satisfactorily, and but one bell is in circuit when a station is called.

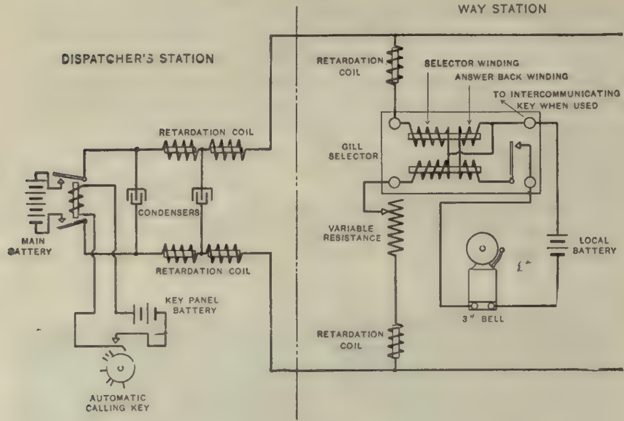


Fig. 720. Local Bell Circuit, Bridged Telephone Selector.

There is no tendency for the bells to tap in other stations than that called, as there is no passing contact and no bell circuit except that selected is closed even momentarily.

G. R. S. SELECTIVE SIGNALING SYSTEM.

The General Railway Signal Co.'s system of selective signaling provides means whereby a dispatcher may call to the telephone, station operators or train crews for the purpose of giving them orders. When a station operator is to be called, it is only necessary to ring a bell letting the operator know that he is wanted on the telephone. When a train crew is to be called, it is further necessary to give a visual signal. If required an "answer back," visual or audible, can be provided as an indication that the system has operated properly.

The system embodies new principles with desirable features, viz.: The method of supplying operating current which results in great economy of operation; the high-speed positive-acting selector, which has a range of 324 different calls and which can close any one of six different circuits at a given station; the calling bells, either a. c. or d. c., of a design similar to the selector; the simple automatic calling key of the messenger call box type, and the system's adaptation to use with any standard telephone equipment.

Stations can be added if so wished without interfering with the operation of existing stations. Each station can be arranged to call any other station.

The selector (Fig. 725) operates on seven milli-amperes, using a new design of pawl and ratchet movement, in which the pawl is forced into position upon the completion of each step and is not dependent upon spring action or gravity for its proper

Energy for the operation of the system is provided by a small motor generator set mounted below the switchboard. The motor operates from a 12-volt battery. The generator is compound wound and supplies current for both bell and selector operation at constant voltage; no local batteries are therefore required at local stations. The motor generator set normally is not running, but is started and stopped automatically with the begin-

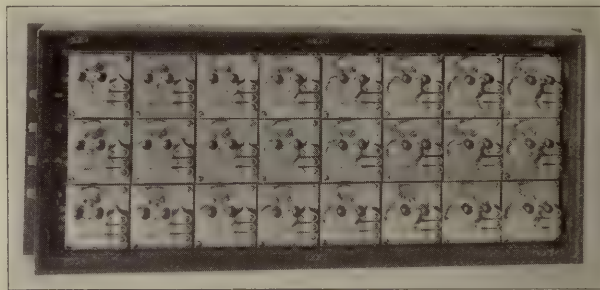


Fig. 721. 24-Station Calling Key Cabinet. General Railway Signal Company.

ning and completion of each call. By the use of this feature each average circuit can be operated at a cost of less than $3 per year.

The switchboard carries a volt-ammeter, necessary switches for the control of the system, underload circuit breaker, ammeter plugs, etc., and a line and motor control relay of the same general design as the selector.

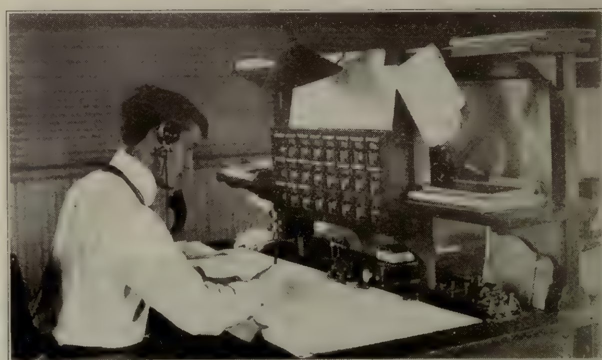


Fig. 722. Dispatcher's Equipment. I. C. R. R.

Fig. 726 shows circuits for operation of a system using d. c. bells. To simplify the circuits a single calling key is shown instead of a number connected in parallel, and likewise on the receiving end of the circuit the station is shown for the key in question only. Contact disks 7-8-9 of key 1 are shown

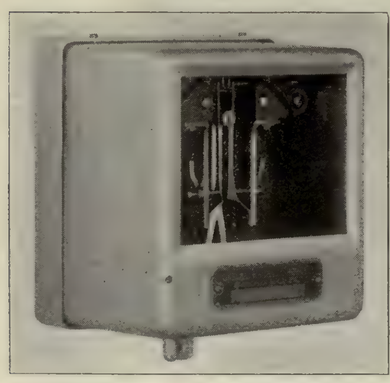


Fig. 723. Line Relay.

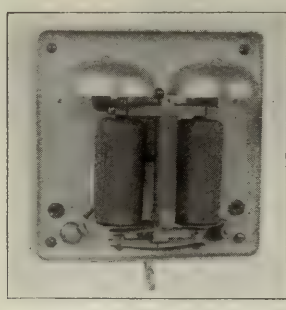


Fig. 724. A. C. Bell.

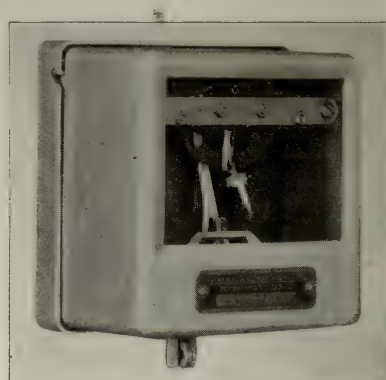


Fig. 725. G. R. S. Selector.

operation. The selector usually furnished will control two circuits. This can be made to control up to six circuits by the addition of contact springs and a mounting block.

Fig. 721 shows a 24-station calling-key cabinet with the front of case removed. Each key may be individually removed from the containing case without disarranging any contacts. The keys are so mounted that all electrical connections are made to bus bars, eliminating the use of wire in the interior of the cabinet.

apart, whereas in reality they are fastened to a common shaft.

To the left of the dotted line is the apparatus located in the dispatcher's office and to the right a local station; 2-3-4-5 are spring contacts closed by rotation of disks 7-8-9 and sector 6; 12 is a 12-volt battery; 13 is the motor, and 14 the generator in the d. c. motor-generator set; 15 and 16 their fields, respectively; 18 a polarized line relay; 19-19 its operating coils, and 26 and 27 are the retardation coils and condenser which make the line available for telephone use.

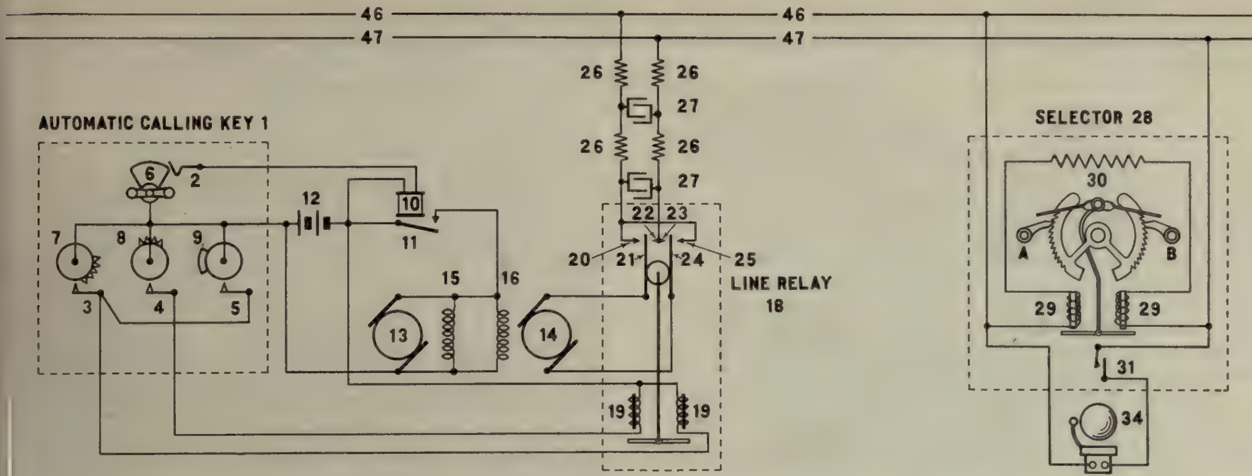


Fig. 726. Typical Selector Circuit Using D. C. Bell. General Railway Signal Company.

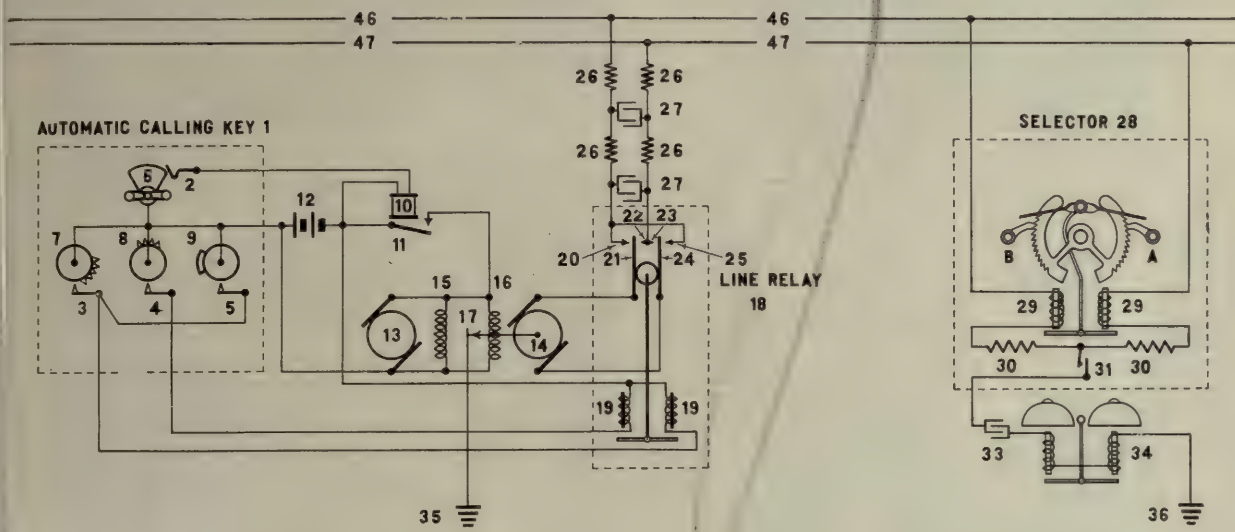


Fig. 727. Typical Selector Circuit Using A. C. Bell. General Railway Signal Company.

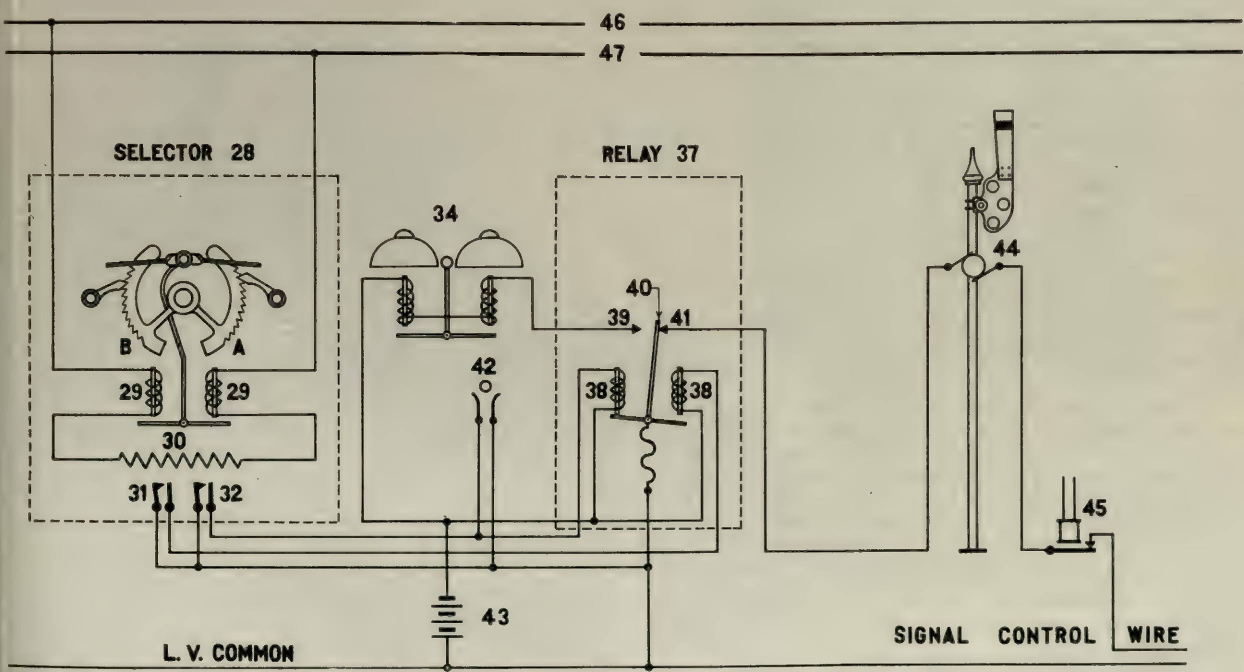


Fig. 728. Selector Used in Connection with Automatic Block Signals. General Railway Signal Company.

To the right of the dotted line is a way station with a selector 28 bridged across the line 46-47; 29-29 are its operating coils; 30 is a variable resistance inserted to balance the line drop; 31 a contact closed by operation of the selector; and 34 is a d. c. bell.

To operate the selector, a small handle fastened to sector 6 of the automatic key 1 is turned clockwise, through an arc of 72 deg. against a spiral spring, thereby making contact between sector 6 and contact spring 2. This picks up motor control relay 10 and starts motor-generator set 13-14 through the closing of contact 11. When the handle is released the contact disks 7-8-9 geared to sector 6 begin one counter-clockwise revolution. The teeth of disk 7 first make contact with spring 3 and thus make and break a circuit which actuates polarized relay 18 once for each tooth on disk 7. This closes contact points 20-21 and 23-24 a like number of times and through them are sent out a number of pulsations on to line 46-47 from generator 14. These pulsations cause the stepping up of the sector A of selector 28 the number of times equal to the pulsations received.

The teeth of disk 8 in making contact with spring 4 likewise send pulsations of current on to line 46-47, but of opposite polarity, and cause the stepping up of the sector B.

The contact arms (not shown) of the selector being rigidly previously described; 37 is a polarized relay similar to relay 18, controlled through contacts 31-32 on selector 28; 44 is a signal mechanism, and 45 is a track relay controlling same. Relay 37 is shown in its normal position, with contact 40-41 closed. The dispatcher in reversing relay 37 breaks the signal circuit by opening 40-41, and rings the bell 34 through the closing of contacts 39-40. The signal if clear will go to block.

The insertion of a telephone plug in the jack 42 at the signal will automatically restore the signal providing there is no train within the section protected by the signal, and cause the bell to stop ringing. This may also be done by the dispatcher through his restoring relay 37 to its normal position.

The selector also may be used in connection with a train dispatcher system in which the movement of trains is governed by means of train order signals. When these are used a distinctive "answer back" is required, either when clearing the signal or putting it to block.

THE BLAKE SIGNAL.

This is a non-automatic signal apparatus by which a number of signals at different points along a railroad are made subject to the control of the dispatcher at a central point. He

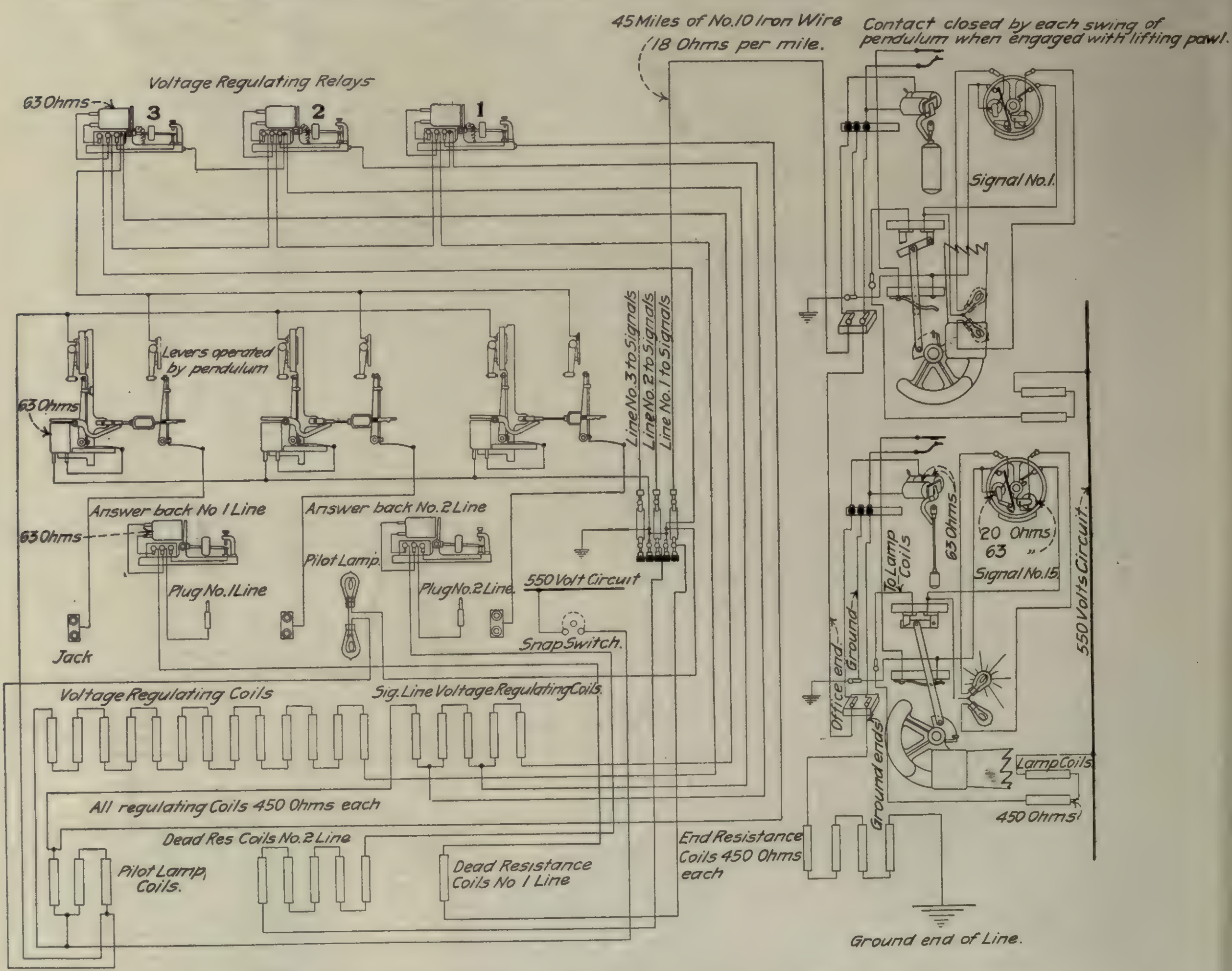


Fig. 729. Arrangement of Circuits for Blake Dispatcher's Signal.

fastened to the sectors A and B will now be in such a relative position that the next impulse, caused by the contact of 9 to 5, will actuate the selector so as to close contact 31, thereby ringing bell 34.

The contact between disk 9 and spring 5 is maintained through 70 deg. of its rotation and through this length of time bell 34 will continue to ring. Circuits formed between 6 and 2, and 9 and 5, are broken simultaneously when all parts return to normal position.

Fig. 727 shows circuits where a. c. bell is used; 17 is a tap from armature winding of generator, carried through armature shaft and insulated therefrom, to ground 35. Alternating current potential will exist between ground 35 and line wires 46-47, and when contact 31 is closed a. c. current will flow from both wires 46-47 through bell 34 and condenser 33 to ground 36, causing bell to ring.

The use of the selector in conjunction with automatic signals is illustrated by Fig. 728. The local station with signal is shown, but not the dispatcher's office. Selector 28 is same as is able to set in the stop position a semaphore of standard size, and by a selective apparatus he controls a number of signals by means of a single wire. The system is used on electric railroads where cars are required to stop at signals, the conductor then inquiring by telephone for orders. The selection is obtained accurately by means of the principle that the time of vibration of a pendulum varies with its length. A No. 10 bare iron wire is used on a line controlling a series of 15 signals.

When the dispatcher wishes, for example, to set signal No. 9 he inserts a plug in hole No. 9 on his desk and thereby releases pendulum No. 9 in the desk and also connects the line with the source of the electric current. As the pendulum in the dispatcher's desk swings it open and closes the circuit, sending impulses over the line synchronous with its vibration. At the end of ten seconds the pendulum at signal No. 9 swings through an arc wide enough to trip a lock and drop the semaphore arm to the stop position. (It is turned upward to indicate proceed.) As soon as the semaphore arm has

reached the horizontal position it throws an interrupted ground on the line at that point, which causes an additional amount of current to flow through the relay on the dispatcher's desk, causing it to attract its armature in unison with the swing of the pendulum; thus the dispatcher receives a positive indication of the semaphore arm being set at "stop."

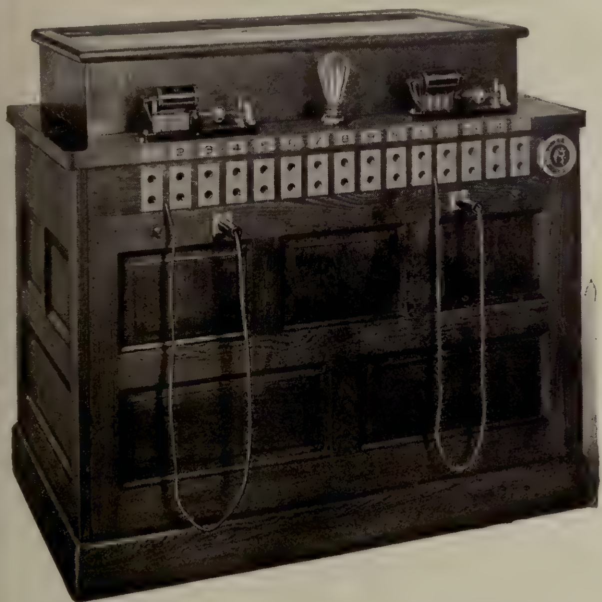


Fig. 730. Dispatcher's Desk; Blake Dispatcher's Signal.

When the car or train has arrived at this point and communicated with the dispatcher by telephone, the dispatcher withdraws his plug and the conductor clears the signal.

WESTERN ELECTRIC SELECTIVE SIGNAL.

The selector shown in Fig. 731, which was developed by the Western Electric Co. for selective telephone calling, has been combined with apparatus made by the Union Switch & Signal Co. to form a selective signal system by which the dispatcher can set any signal at will, the control being carried out to the signals by a single pair of wires. Fig. 732 shows the box mounted on the signal pole which contains the telephone set and local station apparatus and Fig. 733 is a view of the box open showing the selector and the signal operating mechanism. The signal is of standard construction and can be arranged to provide either upper or lower quadrant indications. It is electrically

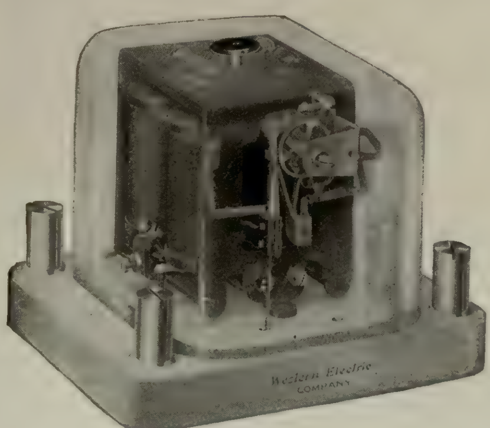


Fig. 731. No. 50A Selector.

operated and manually restored, ten dry cells being required. An important feature of the operation of the system is the distinct "answer back" which the dispatcher receives when the signal movement has been completed.

STROMBERG-CARLSON DISPATCHER'S SIGNAL.

The Stromberg-Carlson telephone train dispatching apparatus consists essentially of clock work mechanisms for selecting local stations from a master station, an electrical trip at each local station for setting the semaphore signal, a clock work mechanism for answering back at the completion of the stroke of the signal trip, and a tape-recording device at the master station, upon which the answer-back records the fact that the signal is gone to danger. The standard clock work selector is driven by a weight which is controlled by a pendulum, so that all

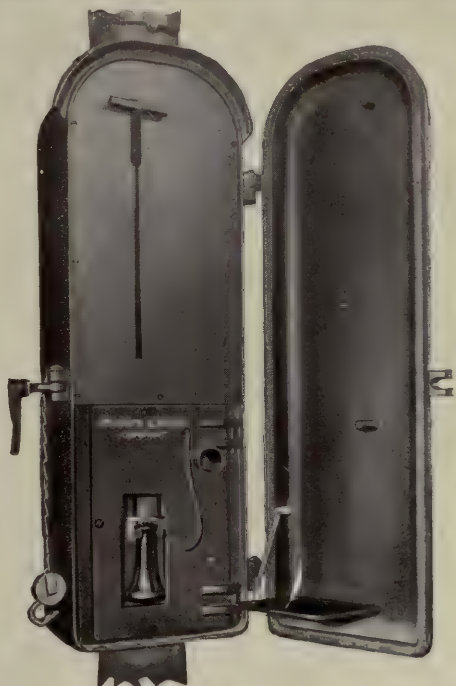


Fig. 732. Pole Casting.

clocks in the system run at the same rate. The operation of the clock rotates a disc carrying a contact finger which moves over a set of contacts, as shown in Figs. 734 and 735. Fig. 734 is the clock mechanism at the master station and Fig. 735 the standard mechanism for the local station. To illustrate the

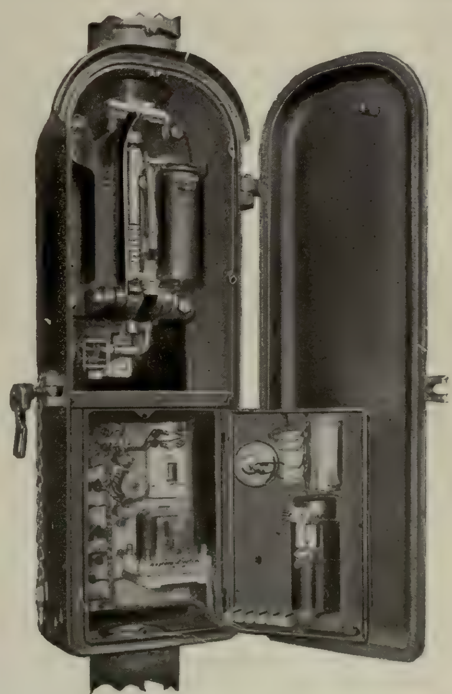


Fig. 733. Apparatus Casting Showing Parts.

procedure in selecting any desired local station, assume that the master clock is regulated so that the contact finger requires three seconds to move from the position shown to the contact marked 2. If the local station mechanism is adjusted so that its contact finger also reaches the second contact in three seconds, it is evident that if a current of electricity is sent over the wire at the end of three seconds from the time the clocks are simultaneously started the circuit will be closed through the apparatus at the local station and any operating mechanism in that circuit will receive current. If it requires three seconds additional for the contact finger of the master selector to move

from contact 2 to 3, and a second local selector is adjusted to close its contact in six seconds, that station will be selected if a current is sent over the wire at the end of six seconds.

The contact finger on the master station selector is arrested by a pin inserted in a hole corresponding with the station which it is desired to call. An electro-magnet operating a friction clutch retains the disc and contact finger in the position at which it is stopped by this pin until a current is sent through the electro-magnet to release the clutch upon which the disc and finger are returned to the zero or starting position by the small weight 2. The local station selector makes contact through a contact segment (1) through the brushes (2). This disc can be set at any desired angle from the brush and this angle governs the period through which the selectors move

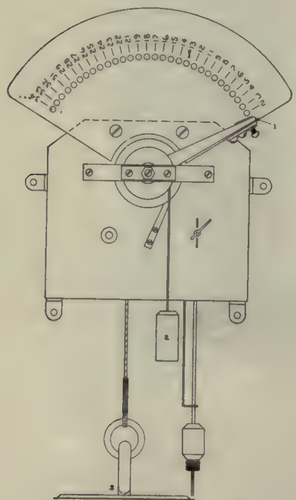


Fig. 734. Master Station Selector.

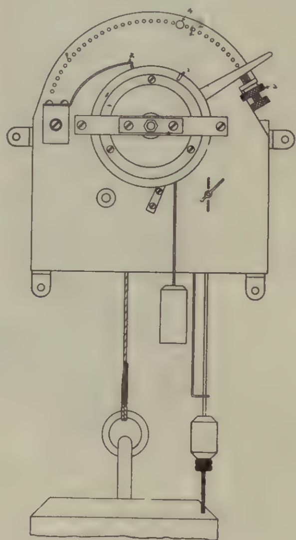
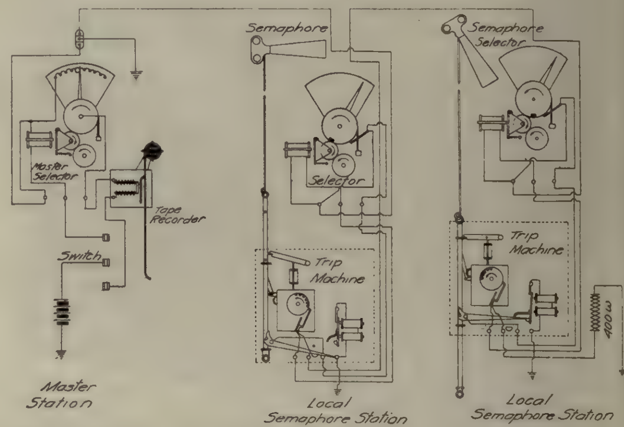


Fig. 735. Local Station Selector.

before that station is selected. An adjusting screw (3) is provided for adjusting this position of the segment accurately. A stop pin (4) arrests the movement of the clock when it has carried the segment in the disc past the brush, since any further movement is unnecessary and results in useless wear. This also materially reduces the amount of winding necessary to keep the clock in continuous operation. Under ordinary conditions it is only necessary to wind the local station clock once in two months, and the circuit is so arranged that if the clock is not wound the current is thrown directly through the trip mechanism at each impulse of current from the master station, resulting in a stop signal which cannot be cleared until the train men wind the clock.

The trip and repeat-back mechanism shown in Fig. 739 consists of a vertical rod mounted in guides on a slate base, which is held locked in its lowest position by the lever 2, which, in turn, is held by a catch 3 on the armature of an electro-magnet. The down position of this rod corresponds to the clear position of the semaphore blade, and when the electro-magnet is energized, tripping the lever and allowing the rod to rise, the signal assumes the danger position by gravity. The repeat-back, which is mounted on the same base, is a clock movement wound each time the vertical rod is returned to its locked position. The vertical rod near the end of its upstroke lifts the release lever 4 of the repeat-back and allows the clock movement to rotate the disc 5. This disc causes breaks in the main line corresponding to the number assigned to the local station at which it is installed. The vertical rod of the trip cannot be returned to its locked position until the repeat-back disc has completed its full revolution and finished registering its number on the recording tape at the master station. The repeat-back mechanism is restored to its normal position by the same operation which returns the signal to the clear position. The tape-recording device consists of a clock movement which carries a paper tape under a perforating pin or point which is attached to the armature of an electro-magnet controlled by the current in the line. When this current is broken by the repeat-back mechanism at a local station a series of holes is punched in the tape corresponding to the number of interruptions made by the local station apparatus. A single pole, double-throw, hand switch is used at the master station to control the application of current to the line.

The operation of the system is illustrated in the diagrammatic drawing shown in Fig. 736. All selectors in the diagram are shown in the resting position, that is, after the movement of the clock has been checked by the pin stops. Under these conditions the first operation is to close the battery switch in the upward position, allowing current to flow through the electro-magnets of each selector, releasing the friction clutch and allowing the discs carrying the controller fingers to return to the zero position. This also releases the clock movement and the pendulums in all clocks begin to beat, allowing them to run at their normal speed. The operator at the master station then selects the desired local station by inserting the pin in the hole in the master selector corresponding to this station, after which he throws the battery switch in the downward position. This removes battery from the line, allowing the electro-magnets to operate the friction clutches which immediately pick up their re-



Figs. 736-738. Diagram Showing Operation of System.

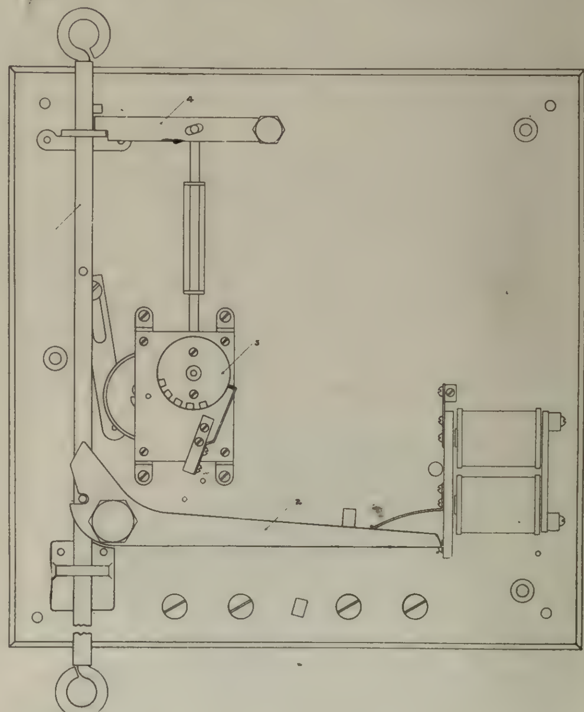


Fig. 739. Trip and Repeat Back Mechanism.

spective discs and the contact fingers are all moved forward simultaneously. The downward movement of the switch also transfers the battery through the tape recorder to the arm of the selector so that when this arm comes into contact with the inserted pin, battery is again placed on the line. At the instant that this contact is closed the contact segment of the station to be selected comes under the brushes and the circuit of comparatively low resistance is closed through the release magnets of this station's trip and repeat-back mechanism. This release magnet operates and cuts itself from the line, allowing the current to flow through the normal line which restores all clocks to the zero position again. The trip release magnet allows the lever and vertical rod to move under the pull of the semaphore which moves to the danger position. The vertical rod as it moves up operates the repeat-back, which in turn records on the tape at the master station, giving evidence that the signal at that station has gone to danger.

INTERLOCKING

Pages 134-296 Figures 740-2088

MECHANICAL

PRINCIPLES OF INTERLOCKING

The concentration of a considerable number of switch or signal levers in the hands of one man would naturally result in the operator at some time mistaking the lever which he was to throw. Through such an error a train might be derailed or diverted from its proper course, or a signal permitting a certain movement might be displayed at the same time another signal permitting a conflicting movement was given. To prevent occurrences of this kind the various levers operating a number of switches and signals placed together in one bank or stand are so interconnected that only proper and non-conflicting movements can be made. This interconnecting of devices used to operate switches or signals so that their movements can only occur in predetermined sequence is called "interlocking," and the assemblage of stands, levers and connections is called an "interlocking machine."

The manner in which the interlocking of the levers is accomplished may be understood by reference to Figs. 740-743; which show a track layout and the locking sheet and dog charts. The dog chart is the working drawing by which the locking is laid out and is a miniature diagram of the locking as it appears in the machine.

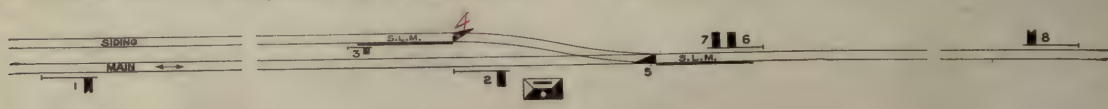
The interlocking plan illustrated in Figs. 740-743 shows a single-track layout, with one siding. A derail is placed at the fouling point on the siding to prevent a car or train on the siding from coming out where it would collide with a train on the main line. The derail and the switch are operated by one lever, No. 5. A dwarf signal is located approximately 55 ft. back of the derail to control movements from the siding. Home signal 2, which is located at the fouling point of the two tracks, protects movements over switch 5. It is placed so as to permit a movement to or from the siding while a train is standing at (in the rear of) it. No. 1 is a distant signal for home signal 2 and is located a sufficient distance in the rear of 2 to enable an engineman to get his train under control before he reaches the home signal, if the distant signal should indicate "caution" when he passed it. Levers 6 and 7 control a two-arm home signal placed about 55 ft. back of the switch point. Lever 7 operates the top arm which governs movements on the main line, and lever 6 the lower arm for movement from the main track to the siding. No. 8 is the distant signal for home signal 7.

The different functions are so connected that when the signalman is operating levers at one end of the machine, the signals, etc., operated will be located at the corresponding end of the interlocking plant. The heavy black line in the tower designates the position of the machine and the dot represents the signalman. These positions should be determined before proceeding to allot numbers to the levers controlling the various functions. When numbering a signaled layout, such as shown in Fig. 740, it is the practice first to number the high signals, then the dwarf signals, for movements in one direction; then part of the spare spaces or levers, if any; then the switches, derails and facing point locks; then the remaining spare spaces or levers; and, finally, the signals for movements in the opposite direction, the numbers running from left to right as the towerman faces the machine.

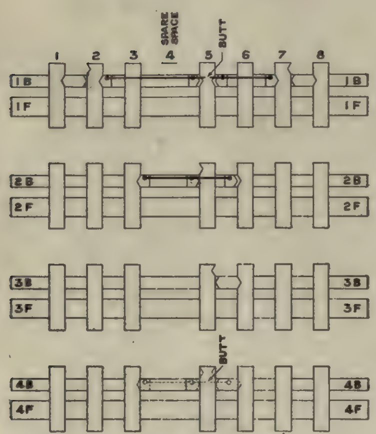
In Fig. 742 is shown a locking sheet for the interlocking plant illustrated in Fig. 740. Before proceeding to make this locking sheet, the routing of the various signals should be determined. When an engineman passes a clear distant signal, it indicates a clear route through the interlocking. Therefore, the reversal of lever 1, controlling the distant signal, should lock home signal lever 2 reversed and 2 reversed should lock switch and derail lever 5 normal, so that switch 5 and home signal 2 will be in their correct positions for a through movement from distant signal 1. Home signal lever 2 reversed should also lock home signal lever 7 normal to prevent the clearing of the two conflicting home signals, 2 and 7, at the same time. Dwarf signal lever 3 reversed should lock switch and derail lever 5 reversed, as the derail should be closed and the switch reversed before a train is allowed to proceed over them. Dwarf signal 3 reversed should also lock home signal lever 6 normal to prevent dwarf signal 3 and home signal 6 from being both in the clear position at the same time. Home signal lever 6 reversed should lock 5 reversed so that switch and derail controlled by lever 5 will be in the correct position for a movement from the main line to the siding. Home signal lever 7 reversed should lock switch and derail lever 5 normal, so that the derail will be open and the switch in the correct position for a movement on the main line. Lever 8 reversed should lock lever 7 reversed, which lever controls the high speed arm of the two-arm home signal, so that when distant signal 8 is in the clear position, derail 5 will be open, switch 5 will be set for the main line and home signal 7 will be in the clear position, thereby setting up a clear route from the distant signal through the interlocking. With all signals normal, lever 5 may stand normal or reversed, the position of switch and derail controlled by that lever being, under these conditions, immaterial. It is apparent that if any of the signals are in the clear position it would be impossible to reverse lever 5, because it would be locked in one position or the other by the reversal of the signal lever. If a train is making a movement on the main line, another train cannot leave the siding, as 5 would be locked normal by 2 or 7 reversed, it being impossible for the signalman to reverse lever 3 unless 5 is reversed. Again, if a train is making a movement to or from the siding, it is impossible to reverse lever 2 and give a clear home signal, as this lever calls for 5 in the normal position and lever 5 would necessarily have to be reversed for the movement to or from the siding.

The locking sheet shows that 2 reversed locks 7 normal, which is the same as 7 reversed locks 2 normal (see dog chart, Fig. 741). This condition prevails in all cases where one lever reversed locks another lever normal, the first lever that is reversed locks the other lever in the normal position.

Before proceeding to make a dog chart it is necessary to ascertain from the locking sheet whether or not any two or more levers lock any other lever or levers in certain positions. Very frequently dogs may be grouped together on one locking



Plan.



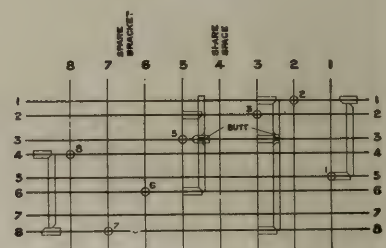
"Standard" Dog Chart.

REVERSE	LOCKS
1	2
2	5-7
3	5-6
4	SPARE SPACE
5	
6	5
7	5
8	7

Locking Sheet.

MACHINE

6 LEVERS FOR 6 SIGNALS
1 LEVER FOR 1 SWITCH AND 1 DERAIL
7 WORKING LEVERS
1 SPARE SPACE: 4
8 LEVER FRAME



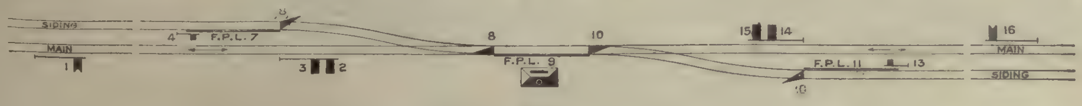
"Saxby & Farmer" Dog Chart.

Figs. 740-743. Interlocking Plan, Locking Sheet and Dog Charts; Single Track and Turnout.

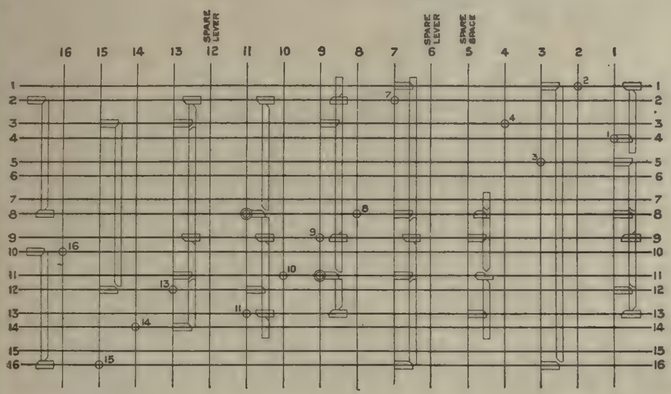
bar, thereby economizing space and material, and it is very often possible, by means of a butt, to avoid duplication of locking bars for the reason that if this were not done two sets of dogs performing exactly the same functions, but using two separate bars and occupying two spaces in the locking frame, would be required. For instance, 2 and 7 reversed lock 5 normal. This is also true of levers 3 and 6 which, when reversed, lock 5 reversed, but it is inadvisable to follow the above method in this particular case, as the butt would have to be placed between dogs on either side of tappet 5, as shown dotted, in the fourth space, and this would leave a very short piece of bar on the double dog to the right of tappet 5, which would be likely to twist to one side and make the butt ineffective. Of course, if cramped for space in a machine, the short bar referred to can be extended to the right and a guide dog fastened to its end. This construction would make such an arrangement satisfactory.

In the locking sheet lever No. 5 is shown as performing for switch and lock movements. This necessitates a slight variation in locking because the facing point lock levers, when reversed, lock the switches either normal or reversed. It is necessary with this arrangement of tracks to make the home signal 2-3 a two-arm signal. The top arm 2 governs movements on the main line, over switches 8 and 10 normal, the lower arm 3, movements to the siding, over 8 normal and 10 reversed.

Notice should be given to the method of numbering the facing point locks, derails and switches. First is facing point lock 7, locking derail 8; then facing point lock 9, locking switches 8 and 10; and, finally, facing point lock 11, locking derail 10. This arrangement of levers insures a good run of the connections operating the facing point locks, switches and derails. It also brings next to one another the levers which are to be operated consecutively; for instance, when a signalman throws switch 8 or 10, he must then throw facing point lock lever 9 to lock it. Furthermore, it simplifies, to a



Plan.



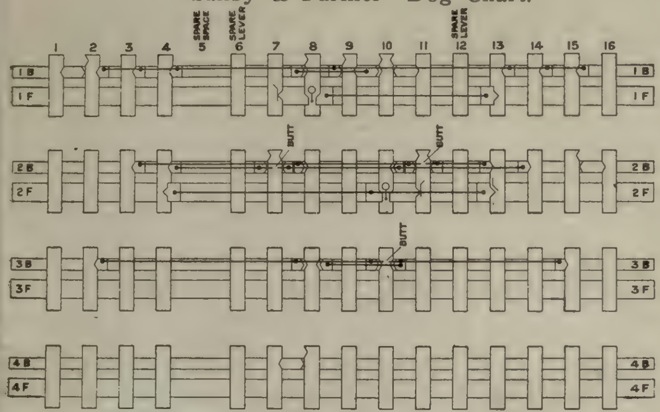
"Saxby & Farmer" Dog Chart.

MACHINE

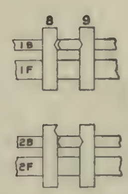
8 LEVERS FOR 8 SIGNALS
2 " " 2 SWITCHES AND 2 DERAILS
3 " " 4 F.P.Ls.
13 WORKING LEVERS
1 SPARE SPACE: 5.
2 " LEVERS: 6, 12
16 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	9	8-8-10-10
2	8-9-10-15	10	
3	8-9-11-13	11	10
4	7-9-14-13	12	SPARE LEVER
W	10 × 11	13	11-9
5	SPARE SPACE	W	8 × 7
6	SPARE LEVER	14	10-9-7
7	8	15	10-9-8
8		16	15

Locking Sheet.



"Standard" Dog Chart.



Details of Locking; Standard Machine.

Figs. 744-749. Interlocking Plan, Locking Sheet and Dog Charts; Single Track, Two Turnouts.

no locking function, but an inspection of the sheet shows that this lever occurs in four combinations, namely 2, 3, 6 and 7 and, if it were desirable, it could be stated in the sheet that lever 5 reversed locks 2 normal and 7 normal; also when 5 is normal it locks 3 and 6 normal; but this is not done as it would be merely a restatement of what is already shown. In the same manner it might be said in the locking sheet that lever 7 reversed locks lever 2 normal. The locking sheet is made up as a guide to the preparation of the dog chart, and everything that appears in the locking sheet should appear in the dog chart. If the repetitions as above stated should appear in the locking sheet, they would appear in the dog chart as unnecessary or overlocks. They are, therefore, omitted.

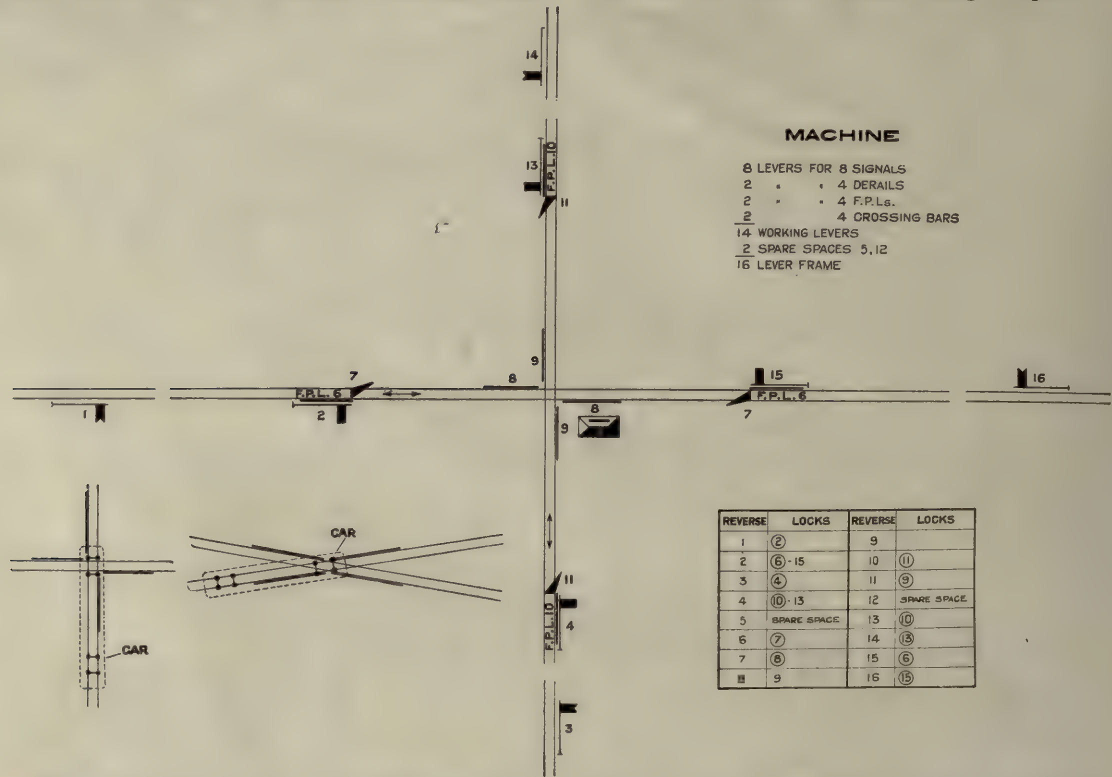
Interlocking plan shown in Fig. 744 differs from that illustrated in Fig. 740 only to the extent of an additional siding connecting with the main line. The signaling necessary to cover this addition is worked out on the same basis as the scheme employed for the single turnout, with the exception of the facing point locks, which have been substituted certain extent, the arrangement of the locking on the dog chart.

As shown on the plan, derail and switch 8 are operated by one lever, as it is always necessary to have both either normal or reversed at the same time. Lever 10, controlling switch and derail, is a similar instance. As it is always necessary to use 9 when either 7 or 11 is being used, it is possible to operate either 7 and 9, or 9 and 11, with one lever; but this is not advisable. With the arrangement as shown it is impossible to reverse 7 unless 8 is reversed. This is also the case with 11 and 10. Therefore, if 7 and 9 were operated by one lever, it would be necessary to lock both the derail and switch 8 in both normal and reversed positions, with this lever. The undesirable feature is this: If the signalman started to reverse switch and derail 8, and the connections between the lever and derail should become disconnected before the derail had started to move, he might complete the reverse movement of lever 8 and leave the derail open without knowing it. He could then reverse 7 (the plunger returning into the same hole in the derail lock rod from which he had just withdrawn it), which would permit him to clear

signal 4. A train from the siding would then proceed and be derailed. One spare space, 5, and two spare levers, 6 and 12, have been provided to take care of future changes.

Such points in the locking sheet (Fig. 747) as differ from locking sheet, Fig. 742, will be now explained. Lever 2 reversed locks 8 and 10 normal; it also locks 9 reversed, which by 3 reversed. Lever 4 reversed locks 7 reversed, which in turn locks 8 reversed; therefore, it is not necessary for 4 reversed to lock 8 reversed direct as it does this indirectly through 7.

As it is possible to make a movement from signal 4 to either the main line or opposite siding, a special condition

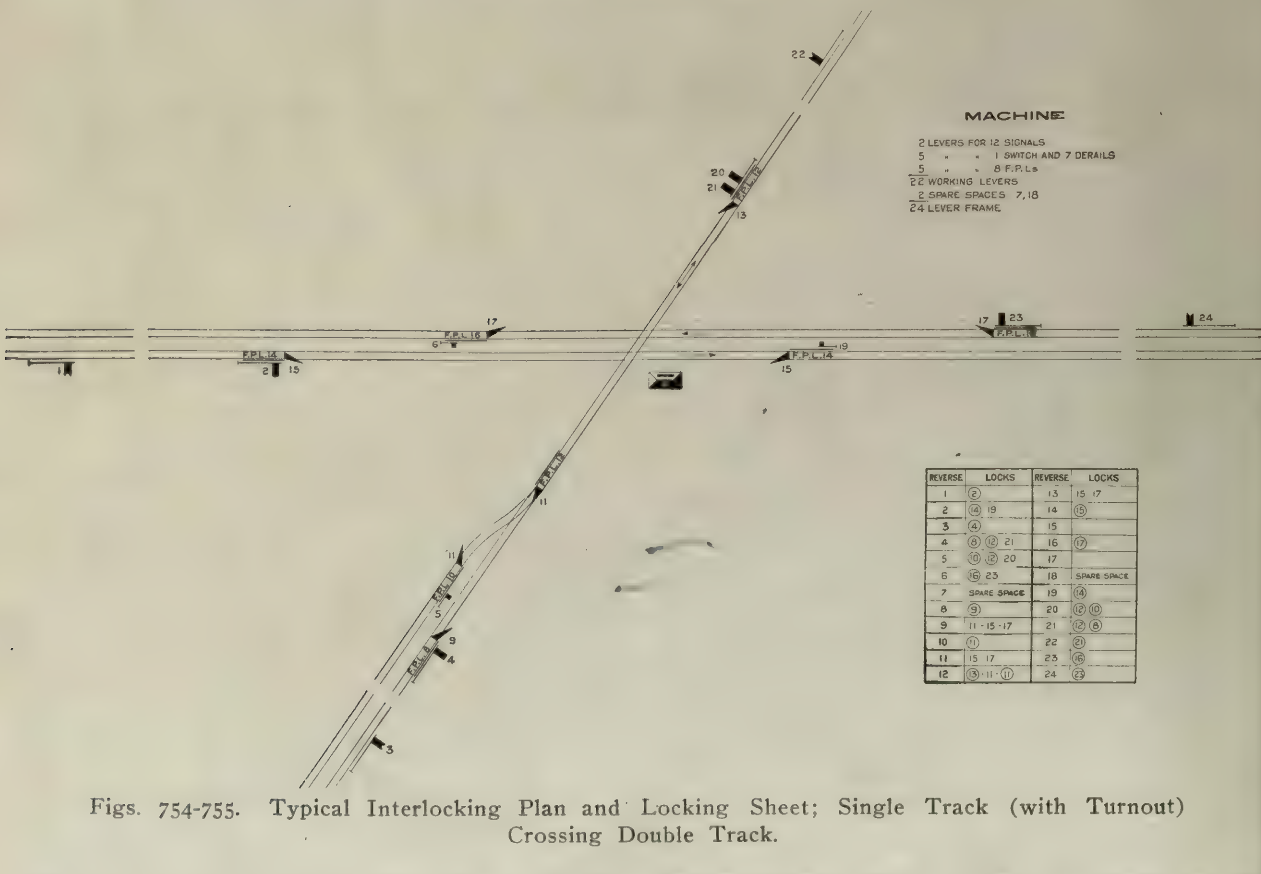


MACHINE

8 LEVERS FOR 8 SIGNALS
2 " " 4 DERAILS
2 " " 4 F.P.Ls.
2 4 CROSSING BARS
14 WORKING LEVERS
2 SPARE SPACES 5,12
16 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	9	
2	6 - 15	10	11
3	4	11	9
4	10 - 13	12	SPARE SPACE
5	SPARE SPACE	13	10
6	7	14	13
7	8	15	6
8	9	16	15

Figs. 750-753. Typical Interlocking Plan and Locking Sheet; Single Track Crossing, Showing the Use of Crossing Bars.



MACHINE

2 LEVERS FOR 12 SIGNALS
5 " " 1 SWITCH AND 7 DERAILS
5 " " 8 F.P.Ls
22 WORKING LEVERS
2 SPARE SPACES 7,18
24 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	13	15 17
2	14 19	14	15
3	4	15	
4	8 12 21	16	17
5	10 12 20	17	
6	16 23	18	SPARE SPACE
7	SPARE SPACE	19	14
8	9	20	12 10
9	11 - 15 - 17	21	12 8
10	11	22	21
11	15 17	23	16
12	13 - 11 - 11	24	23

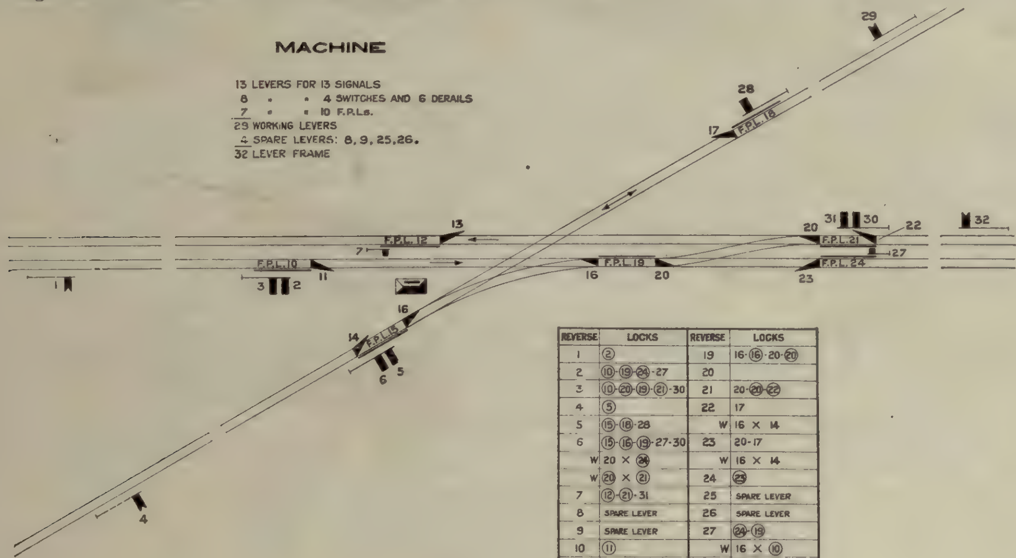
Figs. 754-755. Typical Interlocking Plan and Locking Sheet; Single Track (with Turnout) Crossing Double Track.

in its turn locks 8 and 10 in their normal and reversed positions, both in the locking in the machine and on the ground. Lever 3 reversed does not lock 10 reversed direct, but 10 is locked reversed by 11 reversed, which in its turn is locked arises in connection with the locking. It is evident that the only time that 11 should be reversed is when a movement is to be made over 10 reversed; therefore, the locking would read "4 reversed, when 10 is reversed, locks 11 reversed."

(See dog chart, Fig. 746, which illustrates this and also shows that 11 would remain unlocked with 4 reversed if 10 were normal.)

When making dog charts it is not the practice to indicate in full the tappet pieces (numbers 9A, etc., Figs. 859-900), as the front dogs used in connection with them indicate which

It will be noticed that in the Standard* dog chart (Fig. 746), levers 2, 3, 4, 13, 14 and 15 lock 9 reversed, using only one bar. When combinations of this description are possible they simplify the locking by eliminating a number of dogs and bars that otherwise would be necessary. If one



REVERSE	LOCKS	REVERSE	LOCKS
1	2	19	16-16-20-20
2	10-19-24-27	20	
3	10-20-19-21-30	21	20-20-22
4	5	22	17
5	15-18-28	W	16 × 14
6	15-16-19-27-30	23	20-17
W	20 × 24	W	16 × 14
W	20 × 21	24	23
7	12-21-31	25	SPARE LEVER
8	SPARE LEVER	26	SPARE LEVER
9	SPARE LEVER	27	24-19
10	11	W	16 × 10
11	16-14-17	W	16 × 15
12	13	28	18-15
13	20-17	29	28
W	16 × 14	30	21-20-19
14		W	16 × 10
15	14-16-16	W	16 × 15
16		31	21-12
17	16	32	31
18	17		

Figs. 756-757. Interlocking Plan and Locking Sheet; Single Track Crossing Double Track, with Connecting Track and Crossover.

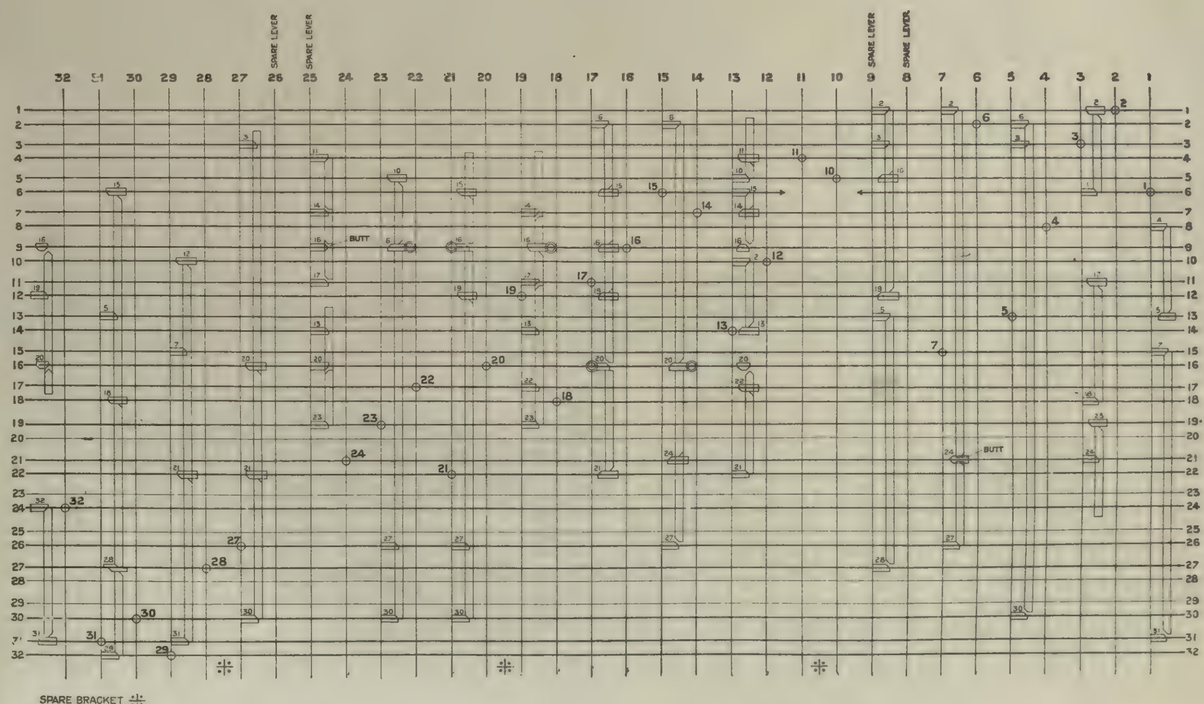


Fig. 758. Saxby & Farmer Dog Chart for Figs. 756-757.

tappet pieces are employed. The special on lever 13 in connection with levers 7 and 8 is similar to the special on lever 4. Lever 14 reversed does not lock 8 reversed direct, as 8 is locked reversed by 7 reversed, which is in turn locked by 14 reversed. If the locking sheet had shown 14 reversed locking 8 reversed, it would have been called an "overlock." This is a duplication of locking already accomplished.

lever reversed locks another lever normal and reversed; for instance, 9 reversed locks 8 normal and reversed, the locking should be arranged as shown in the dog chart and not sep-

*See definition of *Standard Interlocking Machine.* This machine is referred to in this manner throughout the entire description.

arated, as shown in Figs. 748-749. The latter arrangement would make it impossible to reverse 9 whether 8 were normal or reversed. Regarding the arrangement of back locking in the third space of dog chart, Fig. 746, it will be seen that 2 reversed locks 8 and 10 normal. The bar then butts against the top bar to the right of it, consequently holding the dog in the notch of tappet 15 and thereby locking it normal. chart for the locking sheet shown in the figure, the best method of procedure, after becoming familiar with the locking sheet, is first to lay out the locking for the levers on which specials occur. Reference to the locking sheet will show that lever 4 reversed when 10 is reversed locks 11 reversed. Therefore, it is advisable to place the driver operated by lever 4 on one of the bars near the top of the chart; next in order

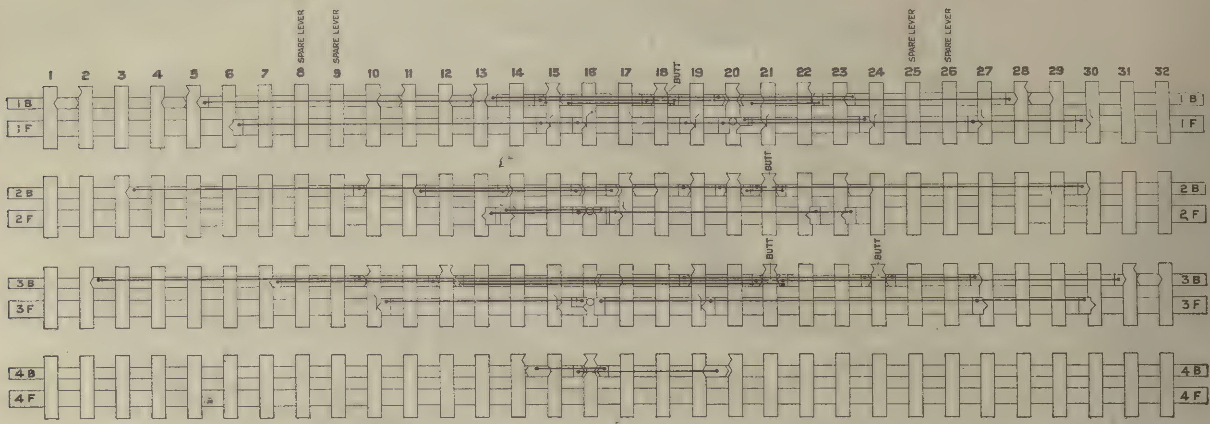
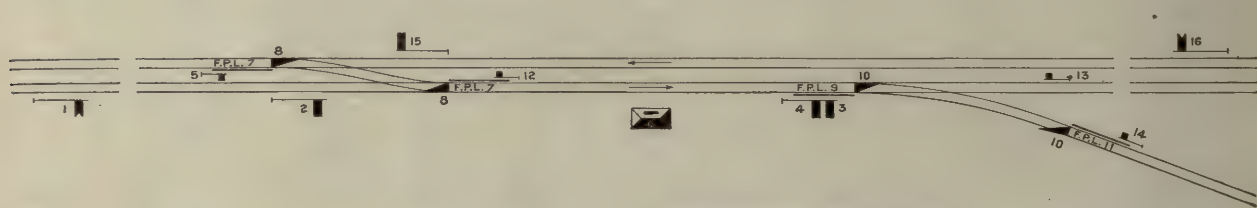


Fig. 759. Standard Dog Chart for Figs. 756-757.

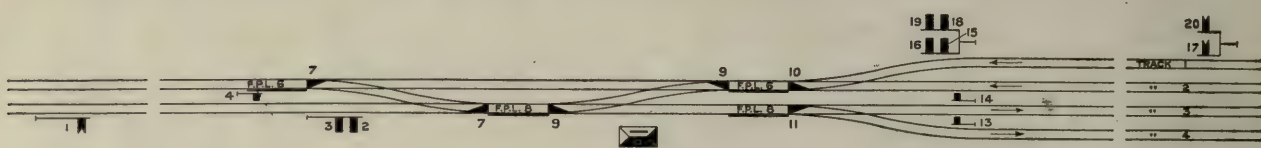


MACHINE

10 LEVERS FOR 10 SIGNALS
2 " " 3 SWITCHES AND 1 DERAIL
3 " " 4 F.P.Ls.
15 WORKING LEVERS
1 SPARE SPACE: 6
16 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2-3	9	10 10
2	8-7 12 13 14	10	
3	9 10 13	11	10
4	9 11-14	12	7
5	7 15	13	10-9
W	8 × 12-13 14	14	11 9
6	SPARE SPACE	15	8-7
7	8 8	16	15
8			

Figs. 760-761. Typical Interlocking Plan and Locking Sheet; Single Track Junction with Double Track.



MACHINE

12 LEVERS FOR 12 SIGNALS
4 " " 6 SWITCHES
2 " " 6 F.P.Ls.
18 WORKING LEVERS
2 SPARE LEVERS: 5, 12
20 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	W	9 X 7
2	7-8-9-11-14	11	9
3	7-8-13-15-18	12	SPARE LEVER
W	9 × 11	13	11-8
W	9 × 6	W	7 × 6
4	6-15-16-18-19	14	11-8-9
W	7 × 9	W	7 × 6
W	7 × 8-13-14	15	10-6-9-8
5	SPARE LEVER	16	10-6-9-7
6	7-7-9-9-10-10	17	16
7		18	10-6-9-8
8	7-7-9-9-11-11	19	10-6-9
9		20	19
10			

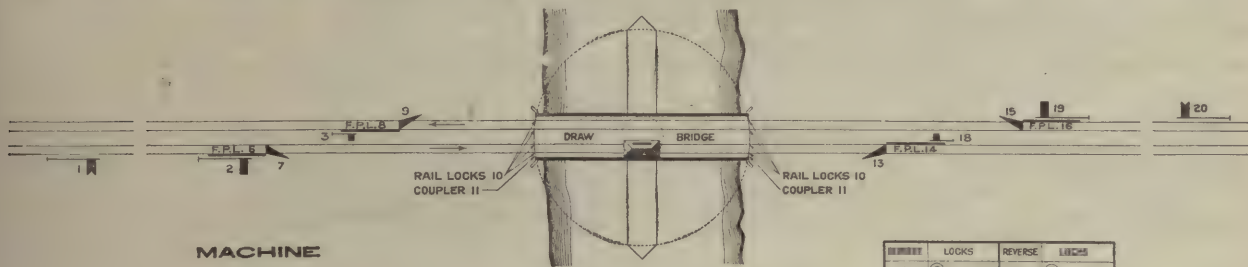
Figs. 762-763. Typical Interlocking Plan and Locking Sheet; Double Track to Four-Track Junction.

Furthermore, when 15 is reversed it locks 10 and 8 normal, as the first and second bars are both fastened to the same dog, which locks lever 10.

The combinations of locking used in making the Saxby & Farmer dog chart (Fig. 745) as shown are considerably different from those found to give the best results with the Standard, this being due to the different construction of the locking. When preparing to lay out a Saxby & Farmer dog should come driver for lever 10; then for 11. After the drivers have been located for levers 4 and 13, the special locking for these levers should be laid out. This will then give an idea of where the rest of the drivers should be located to give the best results.

Figs. 764-765 show typical signaling for the control of a double track drawbridge. The derails for high speed movements are placed about 500 ft. from the draw and those for

reverse movements about 300 ft. It is advisable, at drawbridges, to control the facing point locks and the derails each with a separate lever, as it insures easier and somewhat safer operation. It is apparent that when the draw is opened the connections which operate the various functions must be disconnected to allow the bridge to swing. This is accomplished by couplers operated by lever 11 which, when reversed, make a through connection from the levers to the functions. bridge is closed. The action of reversing 12 indirectly locks all the derails in their normal positions. The derail levers 7, 9, 13 and 15 cannot be reversed until 11 is reversed, as lever 11 couples the connections operating the apparatus, as explained. It is apparent that these connections should not be coupled until the rails are locked in the proper position for a movement over them. Therefore, 11 reversed locks 10 reversed which, in its turn, locks 12 normal, preventing the

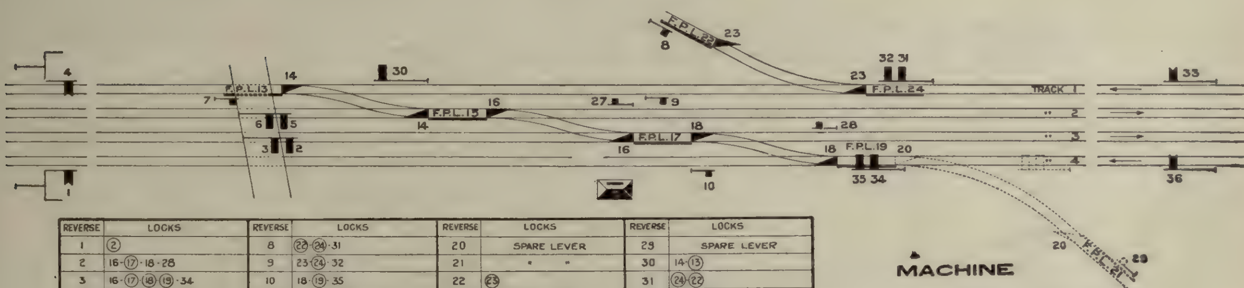


MACHINE

6 LEVERS FOR 6 SIGNALS
4 " " 4 DERAILS
4 " " 4 F.P.Ls
1 " " BRIDGE COUPLERS
1 " " RAIL LOCKS
1 STARTING LEVER · 12
17 WORKING LEVERS
3 SPARE SPACES · 4,5,17
20 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	11	10
2	6 · 14 · 18	12	
3	8 · 16 · 19	13	11
4	SPARE SPACE	14	13
5	" "	15	11
6	7	16	15
7	11	17	SPARE SPACE
8	9	18	14 6
9	11	19	16 · 8
10	12	20	19

Figs. 764-765. Interlocking Plan and Locking Sheet, Double Track Drawbridge.

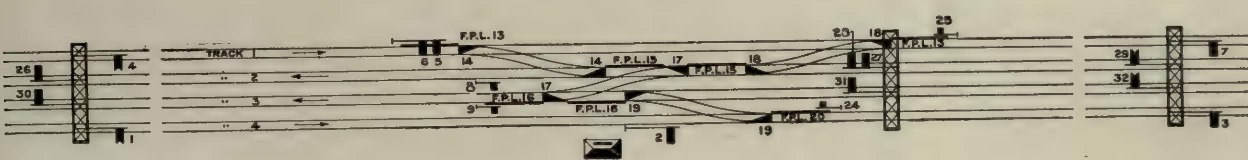


REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	2	8	22 · 24 · 31	20	SPARE LEVER	29	SPARE LEVER
2	16 · 17 · 18 · 28	9	23 · 24 · 32	21	" "	30	14 · 13
3	16 · 17 · 18 · 19 · 34	10	18 · 19 · 35	22	23	31	24 · 22
4	5	11	SPARE SPACE	23		32	24 · 23
5	14 · 15 · 16 · 27	12	" "	24	23 · 23	33	32 · 30
6	14 · 15 16 · 17 28 · 34	13	14 · 14	25	SPARE SPACE	34	19 · 18 · 17
W	18 · × 19	14		26	" "	W	16 × 15
7	13 · 30	15	14 · 14 · 16 · 16	27	16 · 15	W	16 · 14 × 13
W	14 × 32	16		W	14 · × 13	35	19 · 18
W	14 × 15 · 27	17	16 · 16 · 18 · 18	28	18 · 17	36	35
W	14 · 16 × 17 · 28 · 34	18		W	16 × 15		
W	14 · 16 18 × 19	19	18 · 18	W	16 · 14 × 13		

MACHINE

19 LEVERS FOR 19 SIGNALS
4 " " 7 SWITCHES AND 1 DERAIL
6 " " 8 F.P.Ls.
29 WORKING LEVERS
3 SPARE LEVERS: 20, 21, 29
4 " SPACES: 11, 12, 25, 26.
36 LEVER FRAME

Figs. 766-767. Interlocking Plan and Locking Sheet, Crossovers and Turnouts on Four-Track Road.



MACHINE

18 LEVERS FOR 18 SIGNALS
4 " " 8 SWITCHES
4 " " 8 F.P.Ls.
26 WORKING LEVERS
4 SPARE SPACES: 10, 11, 21, 22
2 " LEVERS: 12, 23.
32 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	2 · 3	W	17 × 15 · 27	19	17	26	
2	19 · 20 · 24	W	17 · 18 × 13 · 25	20	19 · 19	27	18 · 15
3		10	SPARE SPACE	21	SPARE SPACE	W	17 × 14 · 13
4	5 · 7	11	" "	22	" "	W	17 × 16
5	13 · 14 · 18 · 25	12	SPARE LEVER	23	SPARE LEVER	28	18 · 15 · 17 · 14
6	13 · 14 · 15 · 25 · 27	13	14 · 14 · 18 · 18	24	20	29	28 · 26
7		14	17	W	19 × 16	30	
8	14 · 15 · 17 · 28	15	14 · 14 · 17 · 17 · 18 · 18	25	13	31	19 · 16 · 17
W	18 × 13 · 25	16	17 · 17 · 19 · 19	W	18 × 14	32	31 · 30
9	16 · 31	17		W	18 × 15		
W	17 · 19 × 20 · 24	18		W	18 · 17 × 16		

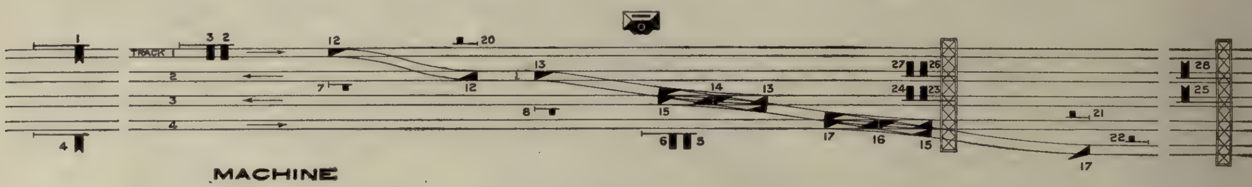
Figs. 768-769. Interlocking Plan and Locking Sheet, Crossovers on Four-Track Road.

The rail locks, operated by lever 10, are arrangements which require the rails to be in a correct position for a movement over them, before the lever operating the rail locks can be reversed, which, indirectly, allows the derails to be closed. "Starting" or bridge-locking lever 12 is so interlocked with the operating mechanism of the drawbridge that it is impossible to operate the draw until 12 is reversed, and lever 12 cannot be returned to its normal position until the drawbridge is closed. opening of the drawbridge. Should a movement be made from signal 2, over the drawbridge, the following procedure would be necessary on the part of the signalman. He would first ascertain that 12 was in the normal position to insure that the draw was locked. This would allow him to reverse 10, thereby locking the rails. He could then reverse 11, which would couple the connections and unlock derails 7 and 13, which he could then reverse; next would follow the reversal

of 6 to lock 7 and of 14 to lock 13, and, finally, the clearing of signal 2. In the figure illustrated, the tower is placed on the drawbridge, although this is not necessary, as it may be located wherever desired to take advantage of circumstances or to satisfy special conditions.

Several peculiar situations are illustrated in Figs. 772-779. Reference to Figs. 772-773 shows that five dwarf signals, controlling movements from tracks 1 to 5, inclusive, are operated by one lever. The connections which operate these signals are so "selected" through switches 2, 3, 4 and 5, that it is possible to clear only one of the five signals at one time. (See Figs. 1021 and 1025.) For instance, when the switches are set in the position shown, the reversal of lever 1 would clear the signal governing movements from track 5 and lock switch 5 in the normal position. It would also lock switches 2, 3 and 4 in whichever position they were when the lever was reversed.

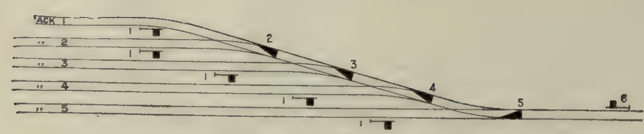
There are two methods of arranging the locking for signal 6; both are shown on the locking sheet, one beneath the other. The first method requires that switches 4, 3 and 2 be locked through a series of specials, the second method that they be locked direct. It is evident that when the first method is used the switches over which the train is to move are locked when lever 6 is reversed. For instance, if a train is to make



17 LEVERS FOR 17 SIGNALS
6 " " 7 SWITCHES, 2 M.P. FROGS AND 1 DERAIL
23 WORKING LEVERS
5 SPARE SPACES: 9, 10, 11, 18, 19.
28 LEVER FRAME

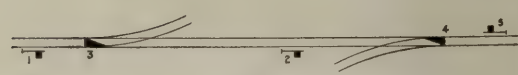
REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	②	W	⑬ × 15-⑮	13		W	⑮-⑬ × ⑭-12-⑫
2	12-20	W	⑬-⑮ × ⑭-17-⑰-21-22	14	⑬-⑮	22	⑰-15-⑮
3	⑫-13-⑬-26-23	W	⑬-⑮-⑰ × ⑯	15		W	⑮ × ⑯-13-⑬
W	⑬ × 15 ⑮	8	15-⑮-13-24	16	⑮-⑰	W	⑮-⑬ × ⑭-12-⑫
W	⑬-⑮ × ⑭-17-⑰-21-22	W	⑮ × 17-⑰-21-22	17		23	⑬-15-12-⑫
W	⑬-⑮-⑰ × ⑯	W	⑮-⑰-× ⑯	18	SPARE SPACE	24	13-15
4	⑤	9	SPARE SPACE	19	" "	25	㉔
5	17-15-21	10	" "	20	12	26	13-⑫
6	⑰-15-22	11	" "	21	15-⑮-17	27	13-12
7	12-13-⑬-27-23	12		W	⑮ × 13-⑬	28	㉗

Figs. 770-771. Interlocking Plan and Locking Sheet, Crossovers on Four-Track Road, Using Double Slip Switches with Movable Point Frogs.



REVERSE	LOCKS
1	2-②-3-③-4-④-5-⑤-6
2	
3	
4	
5	
6	5-⑤
W	⑤ × 4-④
W	⑤-4 × 3-③
W	⑤-4-3 × 2-②
6	5-⑤-4-④-3-③-2-②

Figs. 772-773.



REVERSE	LOCKS
1	3-③
W	4 × 5
2	4-5
3	
4	
5	4-④
W	4 × 3

Figs. 776-777.

REVERSE	LOCKS
1	2-②
W	2 × 3-4
2	
3	
4	3-③
W	3 × 2

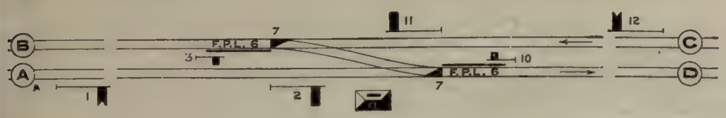
Figs. 774-775.

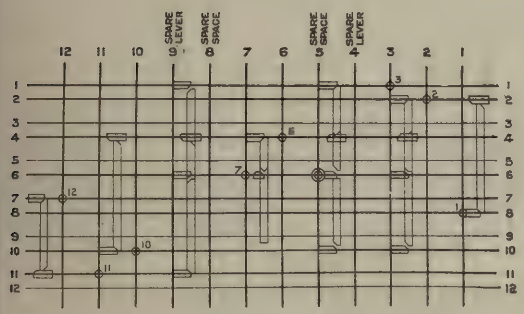
REVERSE	LOCKS
1	3-③-5
W	3-4 × 6
2	4-6
3	
4	
5	3
6	4-④

Figs. 778-779.

Fig. 772-779. Interlocking Plans and Locking Sheets Illustrating Special Conditions.

in the correct position for a movement from one of these tracks, then the reversal of lever 1 clears the signal governing movements from this track. The other four signals remain in the stop position. Fig. 772 shows the switches set in the correct position for a movement from track 5. If lever 1 is reversed the signal controlling movements from track 5 will be cleared. As the various signals operated by lever 1 govern movements over switches 2, 3, 4 and 5, in their normal and reversed positions, it is necessary for lever 1 reversed to lock these switches in both their normal and reversed positions. It is apparent, therefore, that if the switches were a movement from signal 6 to track 5, then switch 5 only would be locked with 6 reversed, thereby allowing the signalman to arrange switches 2, 3 and 4 in position for another movement. When the second method is employed, the locking is simplified by elimination of the specials, but the action of reversing lever 6 locks all switches in whatever position they may then be; and consequently makes it impossible for the signalman to alter the position of any of the switches preparatory to setting up another route while lever 6 is reversed. The point in favor of the first method is that the operation of the machine is facilitated to a certain extent, while with the

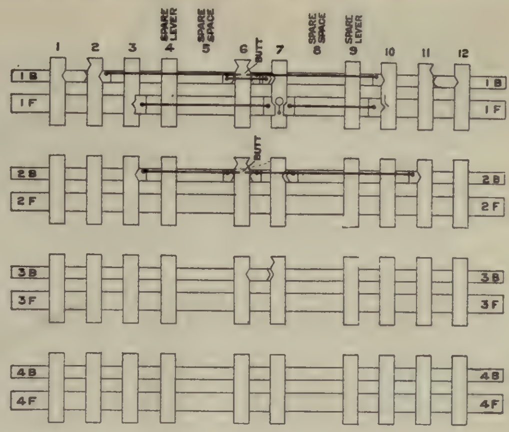




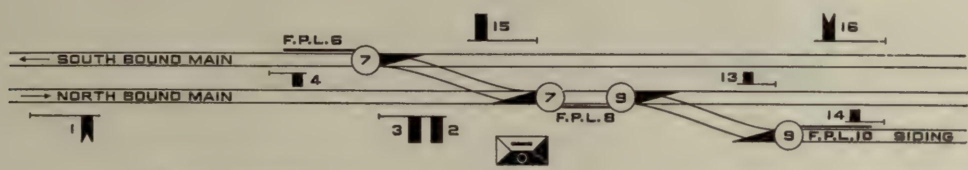
MACHINE

6 LEVERS FOR 6 SIGNALS
1 " " 2 SWITCHES
1 " " 2 F.P.Ls.
8 WORKING LEVERS
2 SPARE LEVERS 4, 9
2 " SPACES 5, 8.
12 LEVER FRAME

REVERSE	LOCKS
1	2
2	7-6-10
3	6-11
W	7 X 10
4	SPARE LEVER
5	SPARE SPACE
6	7-7
7	
8	SPARE SPACE
9	SPARE LEVER
10	6
11	7-6
12	11



Figs. 780-783. Interlocking Plan, Locking Sheet and Dog Charts; Crossover on Double Track.

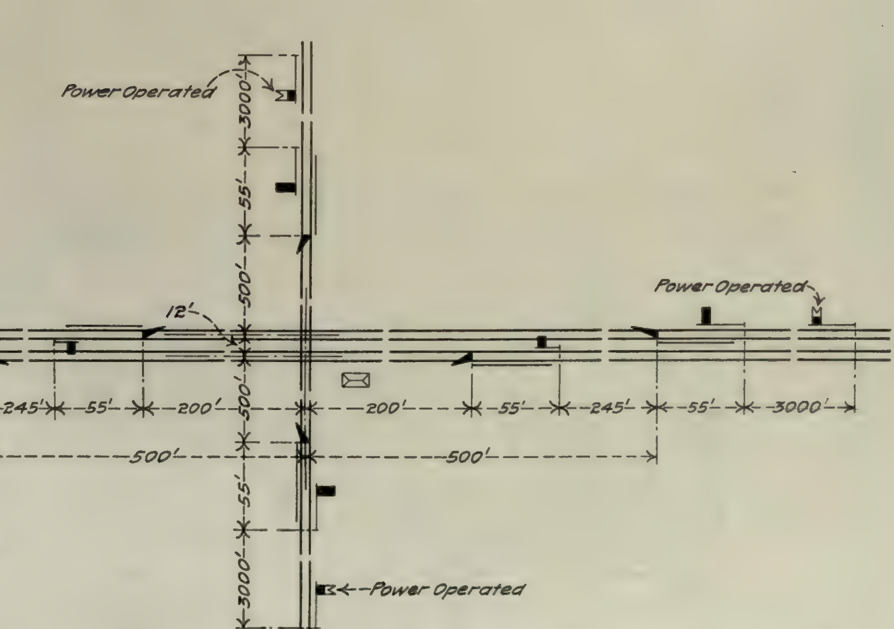


SPARE SPACES: 5, 11, 12.

NORTH BOUND	REVERSE LEVERS					
ON N.B. MAIN DIRECT	8	2	1			
FROM N.B. " TO SIDING	9	10	8	3		
ON S.B. " REVERSE	6	4				
FROM S.B. " TO N.B. MAIN	7	8	6	4		
" S.B. " " SIDING	9	10	7	8	6	4

SOUTH BOUND	REVERSE LEVERS					
ON S.B. MAIN DIRECT	6	15	16			
" N.B. " REVERSE	8	13				
FROM N.B. " TO S.B. MAIN	7	6	8	13		
" SIDING TO N.B. MAIN	9	8	10	14		
" SIDING " S.B. "	7	6	9	8	10	14

Figs. 784-785. Typical Tower Plan and Manipulation Chart.



10 *Levers for* 10 *Signals*
6 *Levers for* 6 *Derails*
16 *Working Levers*

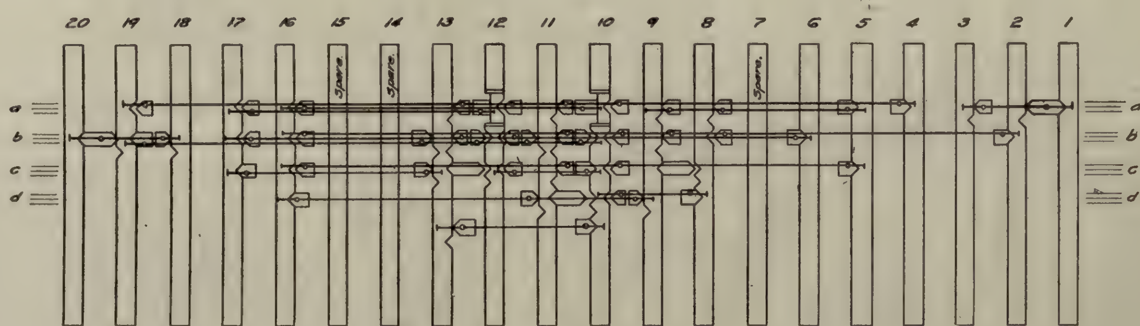
Fig. 786. Standard Interlocking Plan for Single Track Crossing Double Track. New York Central & Hudson River.

Plan.

Locking.	
Lever.	Locks.
1	2 3
2	8 9 10 11 16
3	
4	13 11 (17w 12) (16 w 10)-19
5	8 9 10 11 16
6	12 13 17
7	Spare.
8	10
9	8 8
10	12 13
11	10 10
12	
13	12 12
14	Spare.
15	Spare.
16	11 9
17	13
18	
19	10 11 12 13
20	19 18

Locking Sheet.

11 - Levers for signals.
3 - " " switches.
3 - " " locks.
17 - Working levers
3 - Spare " 7-14 & 15.
20 Lever Machine.



Johnson Dog Chart.

Figs. 787-789. Typical Interlocking Plan, Locking Sheet and Dog Chart for Johnson Interlocking.

Names of Parts of Saxby & Farmer Interlocking Machine; Figs. 790-794.

1 *Lever*
2 *Latch Handle*
3 *Latch Rod Thimble*
4 *Latch Rod*
5 *Rocker Die*
6 *Latch Spring*
7 *Latch Shoe*
8 *Rocker*
9 *Quadrant*
10 *Lever Shoe*
11 *Machine Leg*
12 *Back Tail Lever*
13 *Front Tail Lever (Part of 1)*
14 *Bottom Girder*
15 *Cap for Bottom Girder*
16 *Top Plate*
17 *Locking Bearing*
18 *Universal Link*
19 *Crank*
20 *Locking Bar Driver*
21 *Front Rail with Cap*
22 *Back Rail*
23 *Locking Bracket*
24 *Locking Bracket Cap*
25 *Rocking Shaft*
26 *Cross Locking*
27 *Longitudinal Locking Bar*
28 *Number Plate*

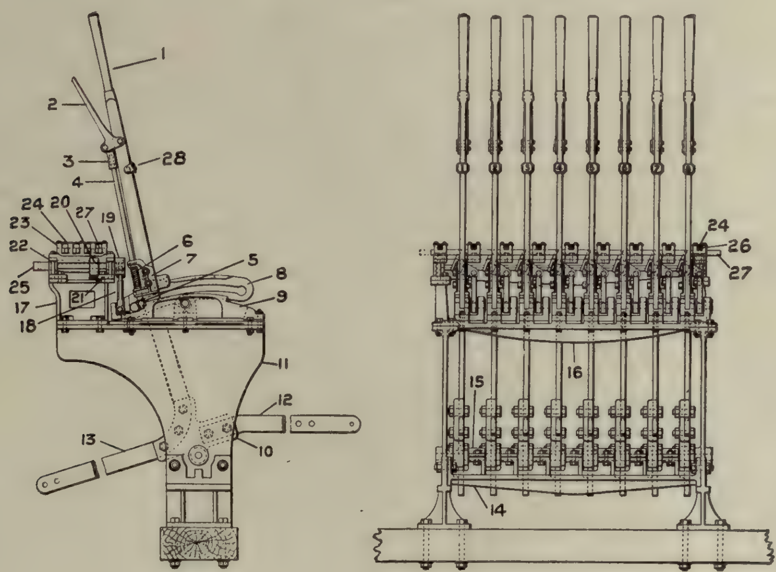
second the locking is considerably simplified as mentioned above.

The layout and locking shown in Figs. 774-775 are illustrated that they may be compared with Figs. 776-779. The locking necessary to be explained in connection with these figures is that occurring between signals 1 and 5 (Figs. 776-777) and between signals 1 and 6 (Figs. 778-779). In Figs. 776-777 lever 1 should not lock 5 normal direct, as it is possible to make a movement from signal 1 to signal 2, or from signal 1 over switch 3 reversed at the same time that a train is moving from signal 5 over switch 4 reversed. Therefore, 1 reversed should lock 5 normal only when 4 is normal. Fig. 778 is similar, except that dwarf signal 5 is added. This signal makes it possible for a train to move from signal 6 to signal 5 while a movement is being made from signal 1 over 3 reversed, and necessitates the following special locking between levers 1 and 6; "1 reversed when 3 and 4 are normal locks 6 normal," it being apparent from the explanation given that, if 3 and 4 are reversed, two movements could be made at the same time.

MACHINES

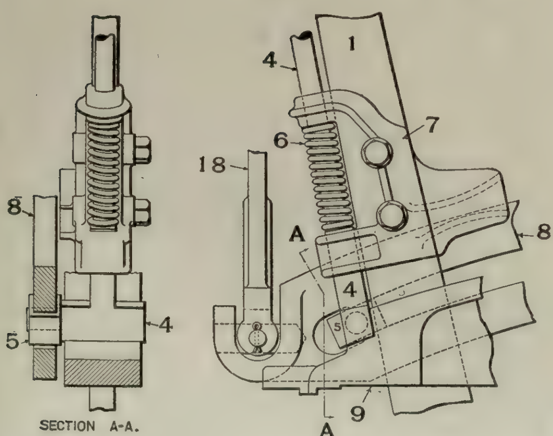
THE SAXBY AND FARMER INTERLOCKING MACHINE.

Figs. 790-794 and 846-850 illustrate a Saxby & Farmer interlocking machine assembled. Figs. 794-845 show various details of the machine. In the following description the numbers refer to Figs. 790-794. The latch handle 2 is pivoted on the lever 1 and is connected to the latch rod thimble 3. This, therefore, imparts motion, when operated, to the latch rod 4 foot of the latch rod 4 (see detail Figs. 792-793) is held on top of the quadrant 9. The latch shoe 7 holds the spring 6 and the latch rod 4 in position. It also acts as a guide for the rocker. The rocker 8 is pivoted at the center of the quadrant 9. The quadrant also acts as a guide for the lever 1. To the lever is bolted the lever shoe 10, which, in its turn, is pivoted on a pin resting on the bottom girder 14. The



Figs. 790-791. Saxby & Farmer Interlocking Machine Arranged for Vertical Leadout.

Numbers Refer to List of Names of Parts on Opposite Page.



Figs. 792-793. Saxby & Farmer Interlocking Machine—Details of Latch Rod Foot.

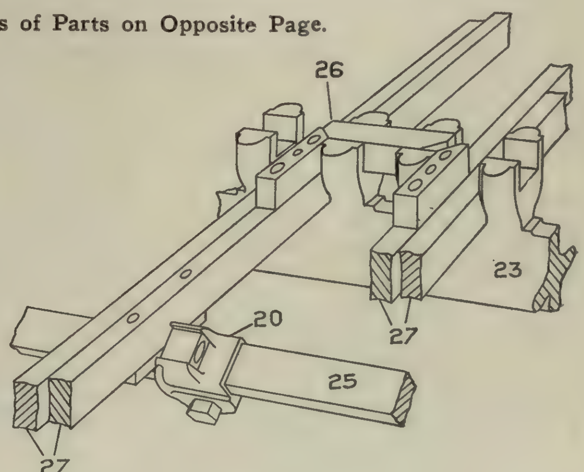
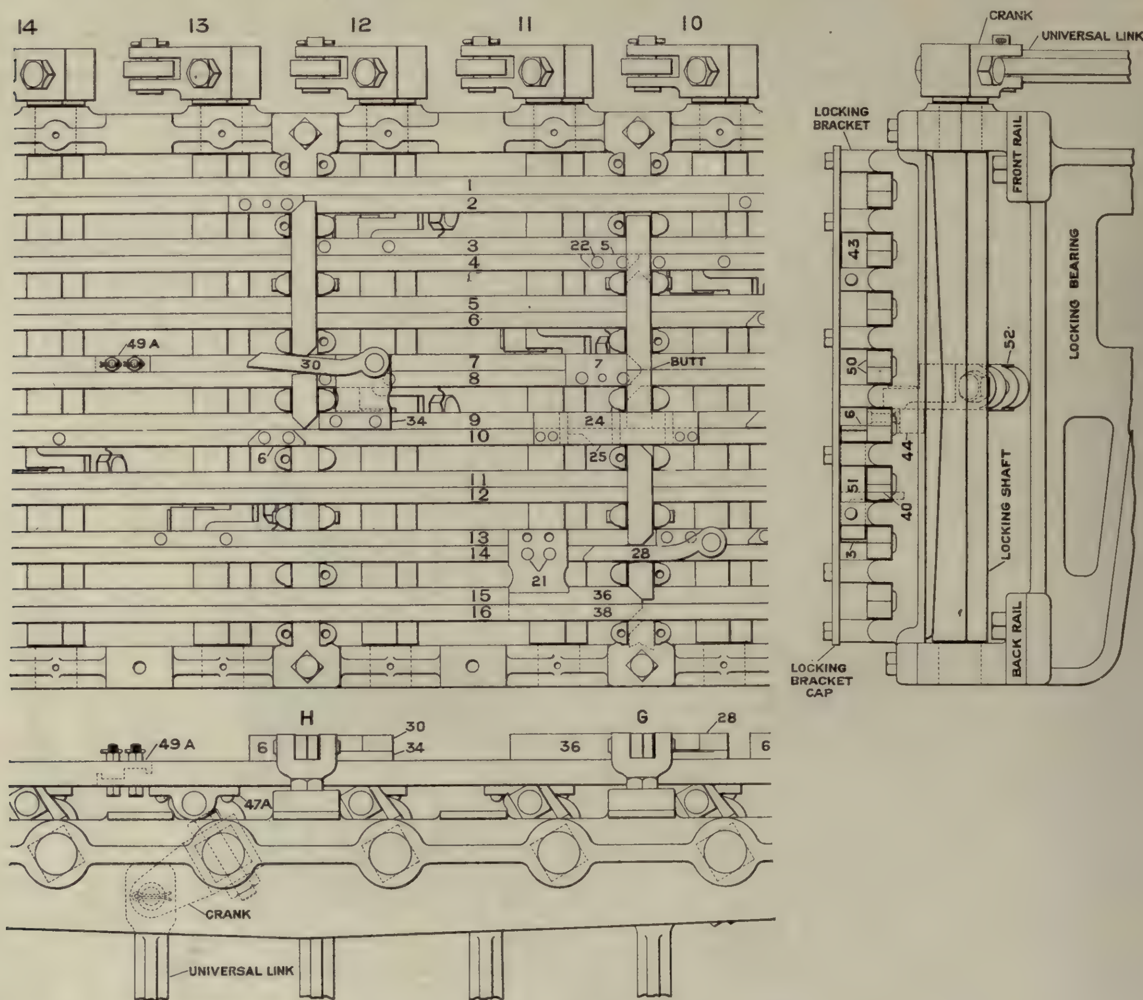


Fig. 794. Detail of Saxby & Farmer Locking.

and the rocker die 5. The latch rod thimble 3 is used to adjust the length of the latch rod 4. The rocker die 5 makes the connection between the latch rod and the rocker. The latch spring 6 is compressed when the latch handle 2 is raised. Upon releasing the latch handle, it is returned to its normal position by the spring 6, unless the lever is between the normal and reverse positions and, in consequence, the back and front tail levers, 12 and 13, are used to connect the levers to the apparatus controlled. The bottom girder 14 is used to support the levers. Cap 15, for the bottom girder 14, holds in position the pin on which lever shoe 10 is pivoted. The top plate 16 carries the quadrants 9 which are bolted to it. Slots are cored in this plate to allow the levers to extend through it. The locking bearing 17 supports the

front rails 21 and back rails 22, which, in turn, act as bearings for the locking shaft 25, and as supports for the locking brackets 23 (see detail Fig. 794). The universal link 18 connects the rocker 8 to the locking shaft crank 19. This crank is rigidly attached to the locking shaft 25. The locking bar driver 20 is fastened to the locking shaft 25. When



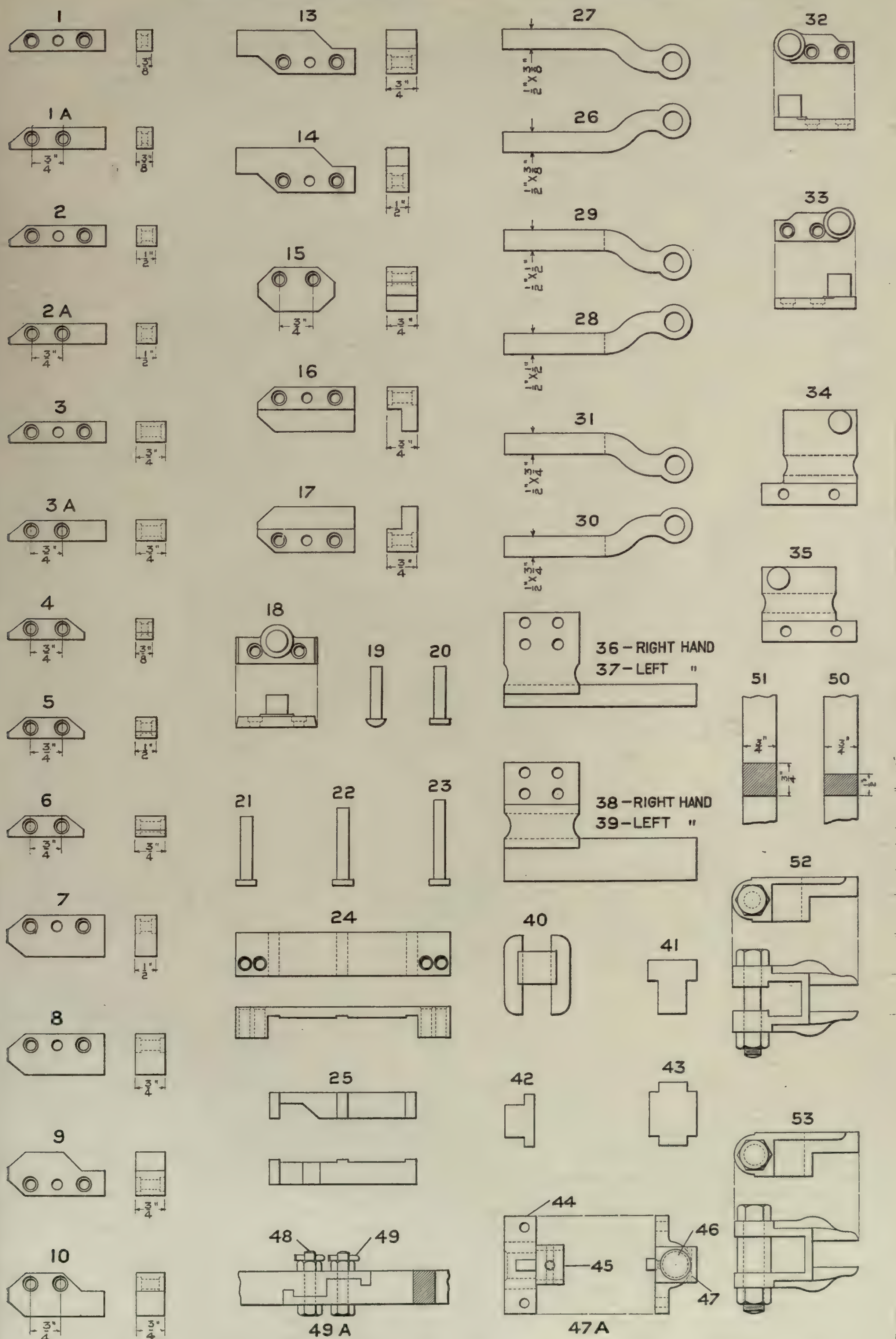
Figs. 795-797. Saxby & Farmer Locking.

Note.—In Figs. 795 and 796 the brackets are illustrated without caps in order to show the locking more clearly.

Names of Parts of Saxby & Farmer Locking Details; Figs. 795-845.

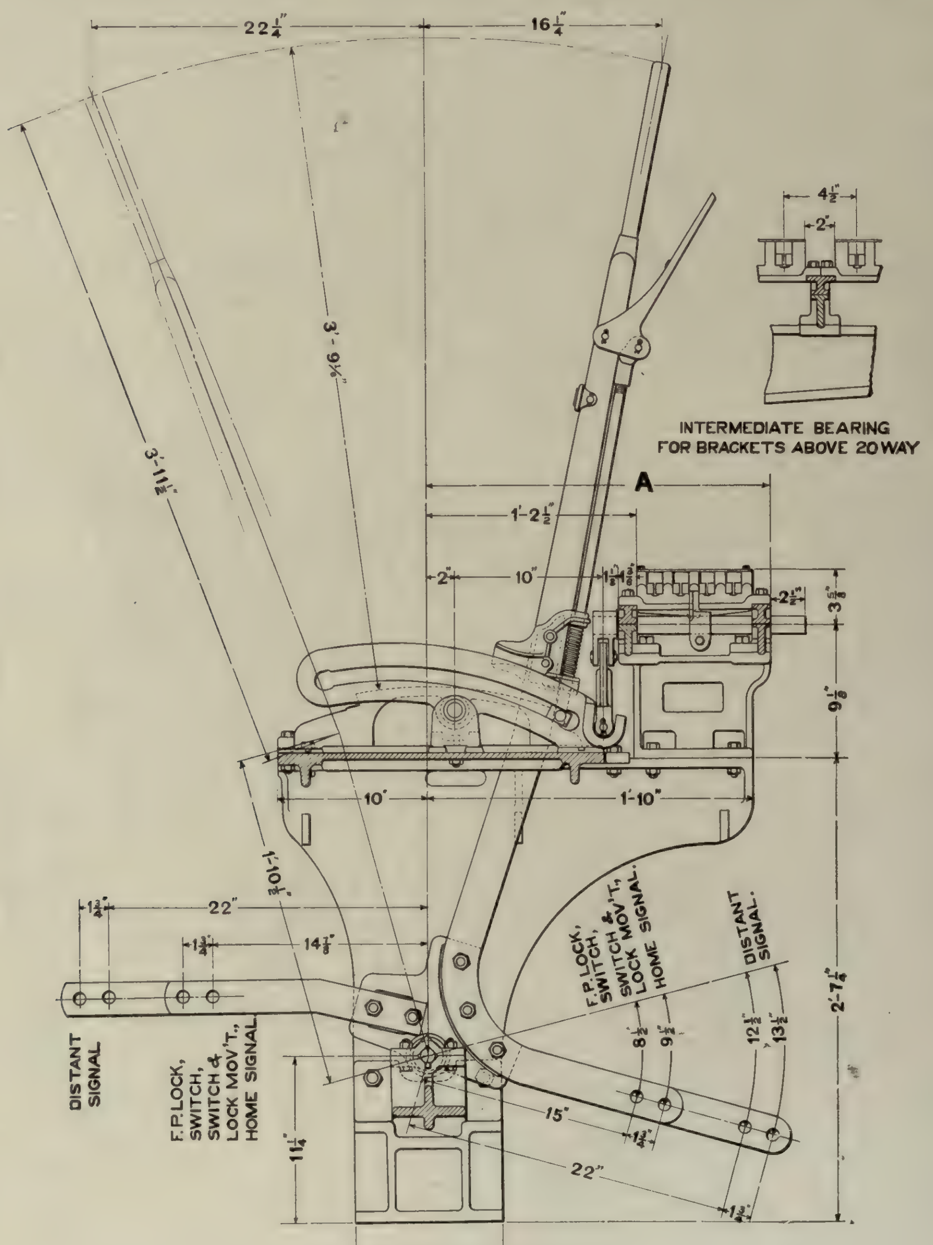
1 *No. 1 Locking Dog, ⅜" x ½"*
1A *No. 1A Locking Dog, ⅜" x ½"*
2 *No. 2 Locking Dog, ½" x ½"*
2A *No. 2A Locking Dog, ½" x ½"*
3 *No. 3 Locking Dog, ¾" x ½"*
3A *No. 3A Locking Dog, ¾" x ½"*
4 *No. 4 Locking Dog, ⅜" x ½"*
5 *No. 5 Locking Dog, ½" x ½"*
6 *No. 6 Locking Dog, ¾" x ½"*
7 *No. 7 Locking Dog, ½" x 1"*
8 *No. 8 Locking Dog, ¾" x 1"*
9 *No. 9 Locking Dog, ¾" x 1"*
10 *No. 10 Locking Dog, ¾" x 1"*
13 *No. 13 Locking Dog, ¾" x 1"*
14 *No. 14 Locking Dog, ½" x 1"*
15 *No. 15 Locking Dog, ¾" x 1"*
16 *No. 16 Locking Dog, ¾" x 1"*
17 *No. 17 Locking Dog, ¾" x 1"*
18 *Right or Left Hand Trunnion*
19 *Rivet, ¼" x 15/16", for Fixing* 44 *to Locking Bars*
20 *Rivet, ¼" x 11/16", for Trunnions*
21 *Rivet, ¼" x 17/32", for ⅜" Locking Dogs*
22 *Rivet, ¼" x 1 11/32", for ½" Locking Dogs*
23 *Rivet, ¼" x 1 19/32", for ¾" Locking Dogs*
24 *Special Locking Dog Guide*
25 *Special Locking Dog*
26 *Left Hand Swing Dog, ⅜" Thick*
27 *Right Hand Swing Dog, ⅜" Thick*
28 *Left Hand Swing Dog, ½" Thick*
29 *Right Hand Swing Dog, ½" Thick*
30 *Left Hand Swing Dog, ¾" Thick*
31 *Right Hand Swing Dog, ¾" Thick*
32 *Left Hand Trunnion*
33 *Right Hand Trunnion*
34 *Left Hand Special Reach Trunnion*
35 *Right Hand Special Reach Trunnion*
36 *Right Hand Special Reach Dog, ½" Wide*
37 *Left Hand Special Reach Dog, ½" Wide*
38 *Right Hand Special Reach Dog, 1" Wide*
39 *Left Hand Special Reach Dog, 1" Wide*
40 *Filling Piece for Locking Bar*
41 *Filling Piece for Cross Locks*
42 *Filling Piece for Cross Locks*
43 *Filling Piece for Cross Locks*
44 *Locking Bar Driver*
45 *Locking Bar Driving Block*
46 *Locking Bar Driving Stud*
47 *Steel Pin, ⅛" x ⅞", for Fastening* 45 *to* 46.
47A *Locking Bar Driver, Block and Stud Comp.*
48 *Hex. Bolt and Nut, ¼" x 1 9/16", for Making Splice in Locking Bars*
49 *Cotter Pin, 3/32" x ⅝", for* 48
49A *Locking Bar, Splice Comp.*
50 *Locking Bar, ½" x ¾", C. D. Steel, Used for Longitudinal Bars*
51 *Locking Bar, ¾" x ¾", C. D. Steel, Used for Cross Locks*
52 *Locking Bar Driver*
53 *Locking Bar Driver*

Numbers Refer to List of Names of Parts on Opposite Page.



Figs. 798-845. Saxby & Farmer Locking Details.

operated it drives the longitudinal locking 27. The locking brackets 23 support the longitudinal locking 27 and the cross locking 26 (Fig. 794). The locking bracket caps 24 are used to hold the locking 26 and 27 in position (see detail Figs. 795-797). The locking shaft 25 makes the connection between the crank 19 and the locking bar driver 20. Fig. 794 shows a perspective view of cross locking 26 and longitudinal locking 27. A number plate 28 is placed on each lever, levers being numbered consecutively from left to right. The the latch rod foot has, by the lowering of the latch handle, engaged with the stop on the quadrant. This holds the lever in position and completes the throw of the longitudinal locking. When a signalman desires to operate a lever, he raises the latch handle. This imparts an upward motion to the latch rod and rocker die and gives the rocker one-half of its full throw. The rocker transmits an upward motion to the universal link. This, through the medium of the crank, turns the locking shaft. Turning the locking shaft gives,



Figs. 846-847. Outline of the Saxby & Farmer Interlocking Machine; Arranged for Vertical Leadout.

levers as shown in the machine are said to be in the normal position. When in the opposite position, they are said to be reversed. The locking shafts 25, when operated, turn in bearings on the rails 21 and 22.

To convey a clear idea of the operation of the locking in an interlocking machine, it will be necessary to give an explanation of preliminary latch locking. A lever in a machine is held in position until the latch rod foot (Figs. 792-793) has been raised above the quadrant, by the raising of the latch handle. Through the rocker and locking shaft, this movement of the latch handle imparts one-half of the full throw to the longitudinal locking. This, in turn, actuates the cross locking and locks all conflicting levers that before this action were unlocked. It keeps locked all levers that should remain locked, until the lever is moved to its opposite position and through the locking bar driver, one-half of the throw to the longitudinal locking and this, in turn, gives the full throw to the cross locking. When the lever is fully moved to the opposite position, the latch spring forces the foot of the latch rod into engagement with the stop on the quadrant, thereby imparting the other half of the throw to the rocker and, consequently, to the longitudinal locking. It can readily be understood that throwing the lever does not transmit any motion to the locking and that it is impossible to release a lever which should not be thrown because the latch cannot be raised. As very little power can be applied to the latch handle, the strain on the locking is small compared with that in machines where the locking is actuated by the movement of the lever.

Figs. 743, 745, 758, and 781 show dog charts for Saxby &

Farmer interlocking machines. The long horizontal lines represent the locking bars and are numbered in the order in which they are placed in the machine, commencing with the one next to the levers. A small circle drawn on this line shows by which lever the bar is worked and where the connection is made. Locking brackets are numbered to correspond with the levers. Cross locking is stamped with the number of the bracket in which it is to be placed. It is also stamped at each end with the number of the locking bar under that end. This for as many dogs as there are levers to be locked. (See Fig. 795, bracket G.) Reversal of the locking lever forces the cross locking over against the dogs of the other levers and locks them. If one of the other levers has been reversed, the cross locking will strike against the dog of that lever and prevent the lever from being reversed.

Special locking is shown at 30, bracket H, in Fig. 795. This is used when one lever is to lock a second lever only when a third lever is in a given position. It consists of a dog of

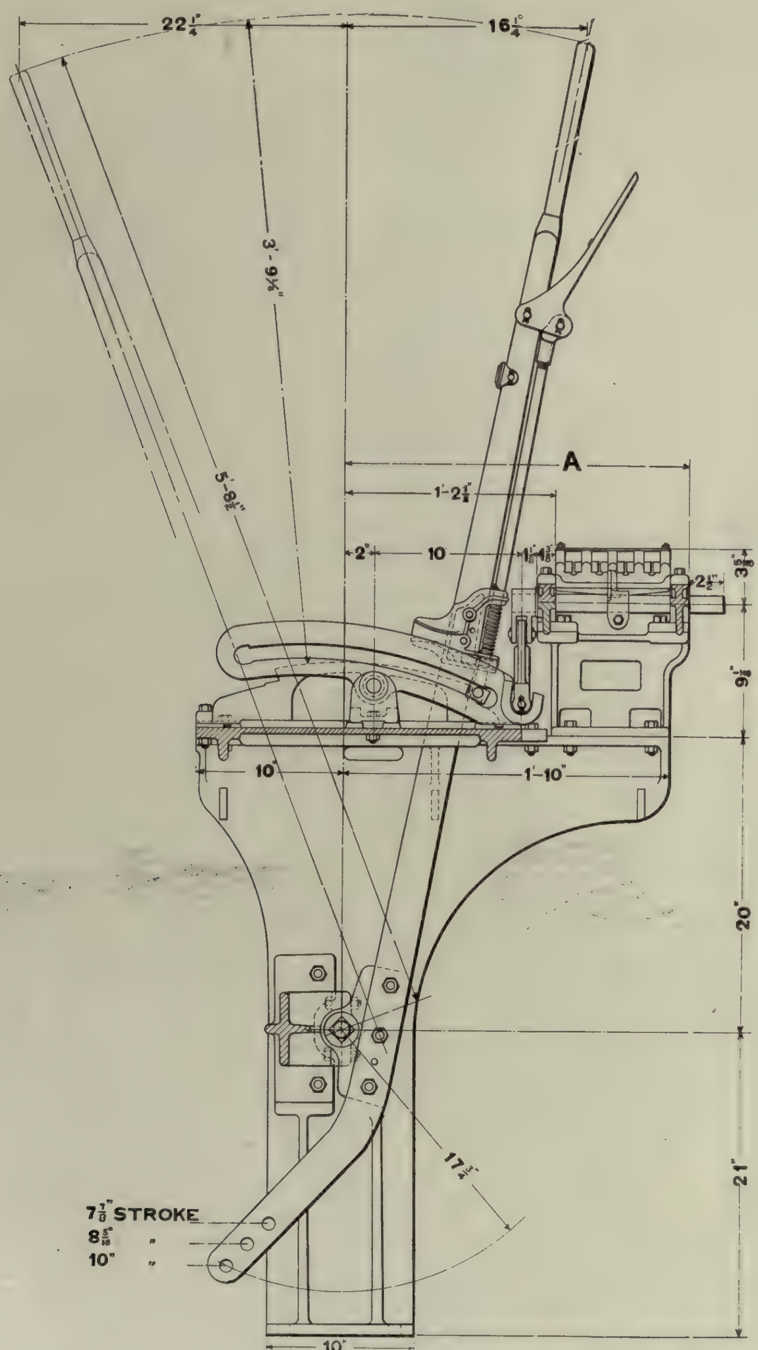


Fig. 848. Outline of the Saxby & Farmer Interlocking Machine; Arranged for Horizontal Leadout.

is done in order that the bars and cross locking may be easily replaced in the machine if they have been removed for any reason. The cross locking is represented as being placed close to the dog by which the locking is performed; the clearance necessary to allow it to be moved is left next to the other dog. This is done in order to facilitate reading of the dog chart by showing which lever does the locking. When one lever locks two or more levers the cross locking is notched special form pivoted on the locking bar so that it can be moved sidewise by the two pieces of cross locking between the edges of which it projects. It also moves lengthwise with the longitudinal bar to which it is pivoted. In the position shown the two pieces of cross locking act as one, as the clearance space between them is taken up. If the special swing dog is withdrawn it will allow either of the two pieces of cross locking to be moved and the first and second lever

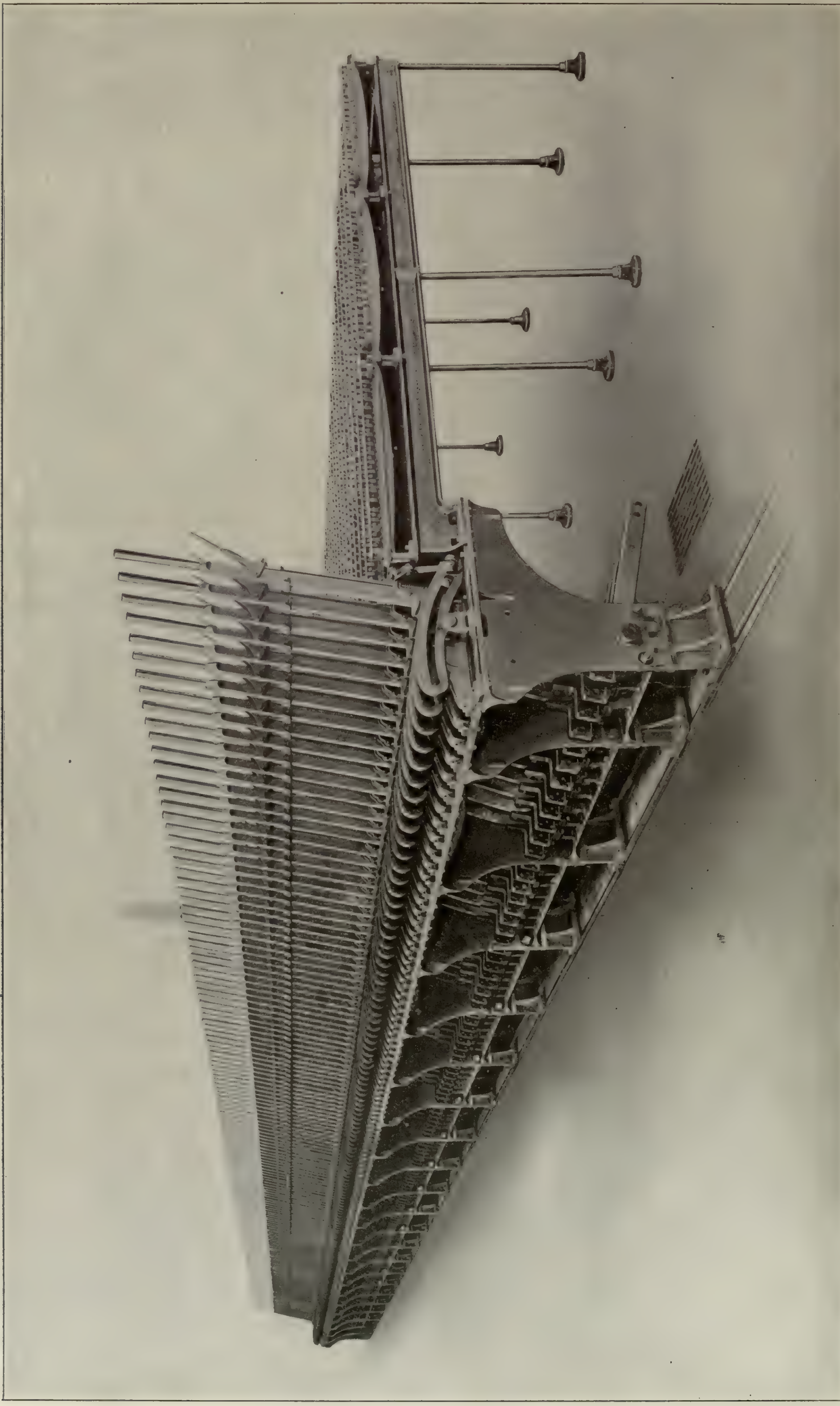


Fig. 849. One-hundred-and-seventy-two-Lever Saxby & Farmer Interlocking Machine Assembled in Factory.

reversed regardless of each other, and if both are reversed, the lever which carries the swing dog is locked.

THE STANDARD INTERLOCKING MACHINE.

As many of the parts of the Standard machine (Figs. 851-902) are similar to those of the Saxby & Farmer (Figs. 790-850), such parts only as are different will be explained. The latch block and roller (see detail Figs. 853-854), do the same work as the foot of the latch rod and the rocker die in the Saxby & Farmer machine. The latch block 6 is also used to adjust the length of the latch rod. The segment 7 is of slightly different design, but performs the same function as the quadrant used with the Saxby & Farmer machine. The

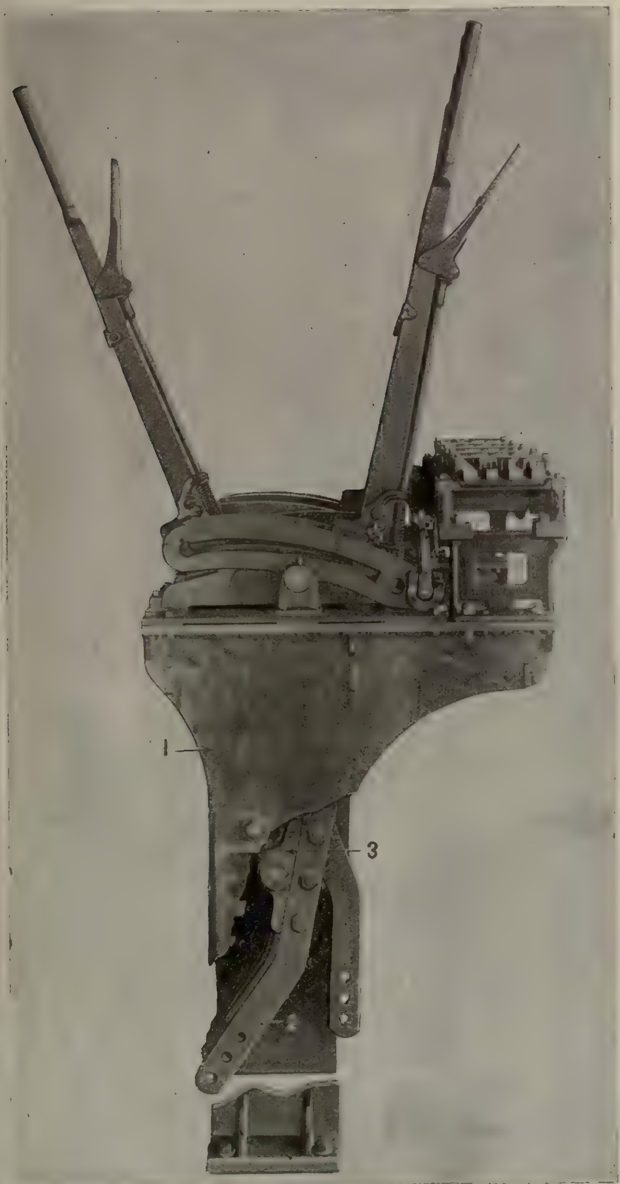
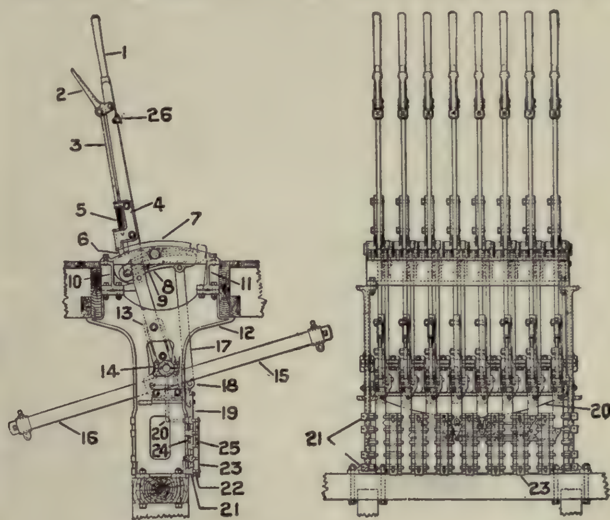


Fig. 850. The Saxby & Farmer Horizontal Leadout.

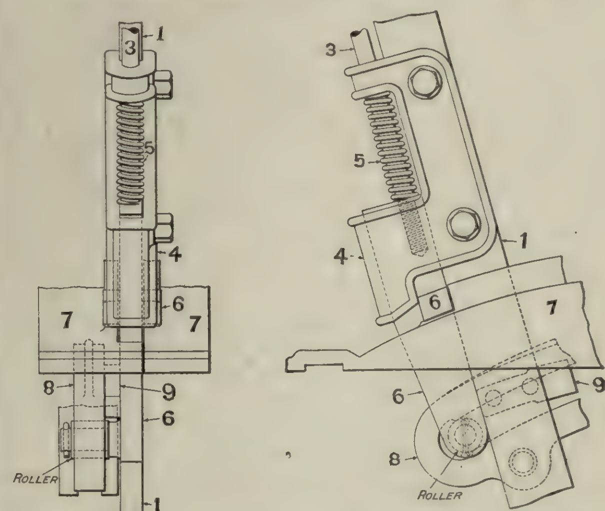
rocker 8 has a lug cast on one end which extends through and above the segment, upon which the signalman may press with his foot, and thus with less effort raise the latch handle 2. The rocker guide 9, which is riveted to the lever, acts as a guide for the rocker. The back and front girders 10 and 11, respectively, support the segments. The back girder also acts as a stop for the levers. The tappet connecting link 17 connects the rocker 8 to the tappet 19. The tappet jaw 18 is rigidly screwed to the tappet 19, which directly actuates the back and front locking, 24 and 25 (also see detail Figs. 855-858). The locking plate 21 supports the back and front locking 24 and 25 and guides the tappets 19. The back locking 24 is placed in the same plane as the tappets between which this locking is accomplished. The front locking 25 is placed in front of the back locking. The front locking guides 22 are screwed to the locking plate 21, to support and guide the front locking. The locking plate strip 23 is placed in front of the front locking to hold it in place.

The operation of the Standard machine, which accomplishes practically the same results as that of the Saxby & Farmer, is as follows: When the signalman desires to operate a lever, he first raises the latch handle, which, in its turn, raises the latch rod and latch block and compresses the latch spring (Figs. 853-854). This releases the lever and at the same time gives the rocker one-half of its throw. The rocker transmits its throw through the connecting link to the tappet and locking. When the lever has been moved to the opposite position, the latch spring forces the latch block into engagement with the stop on the segment, and it thus imparts the



Figs. 851-852. Standard Interlocking Machine.

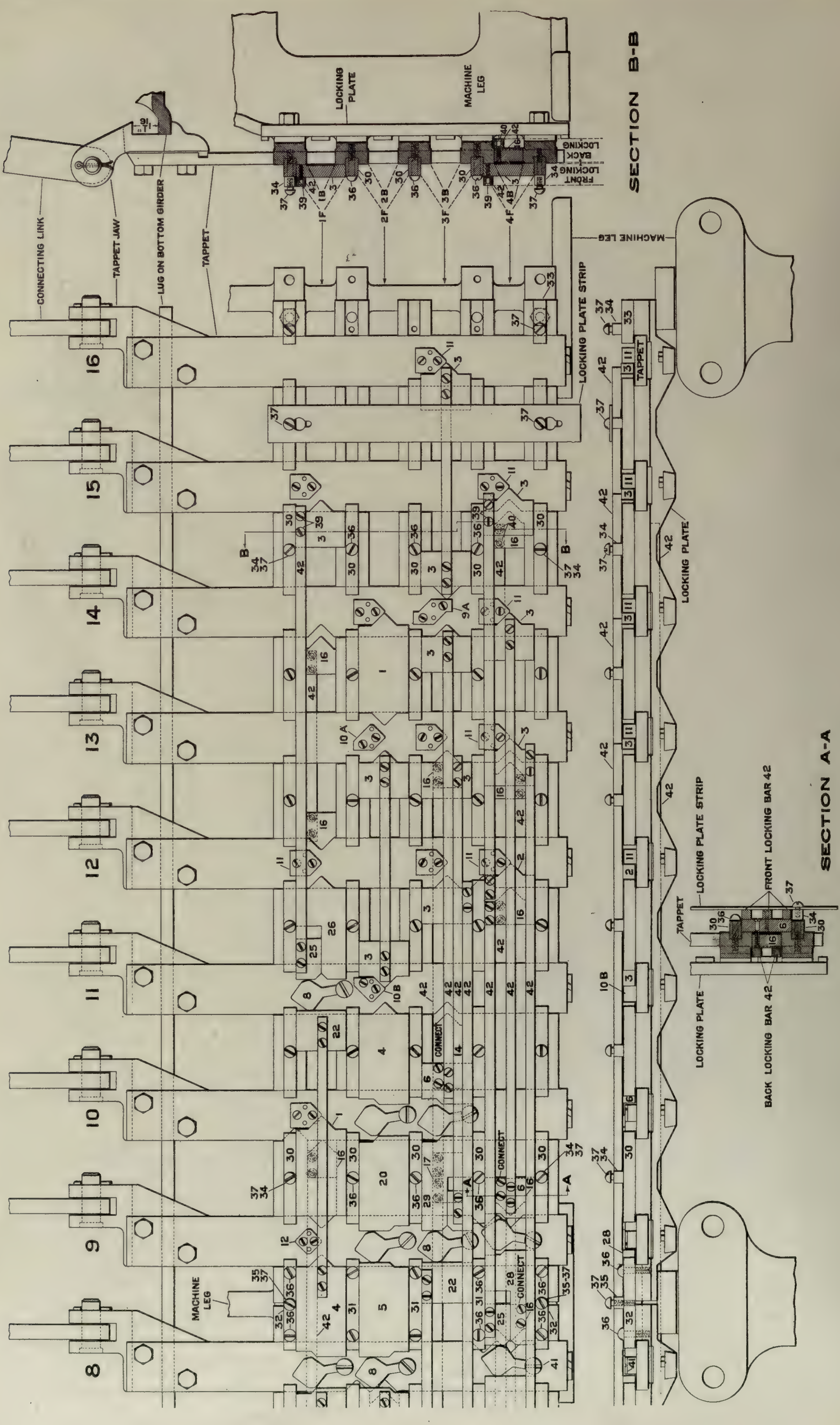
other half of the throw to the rocker, and, consequently, to the tappet and locking. The locking plates, which are attached to and supported by the machine legs, are constructed with four separate spaces for locking. The upper space is



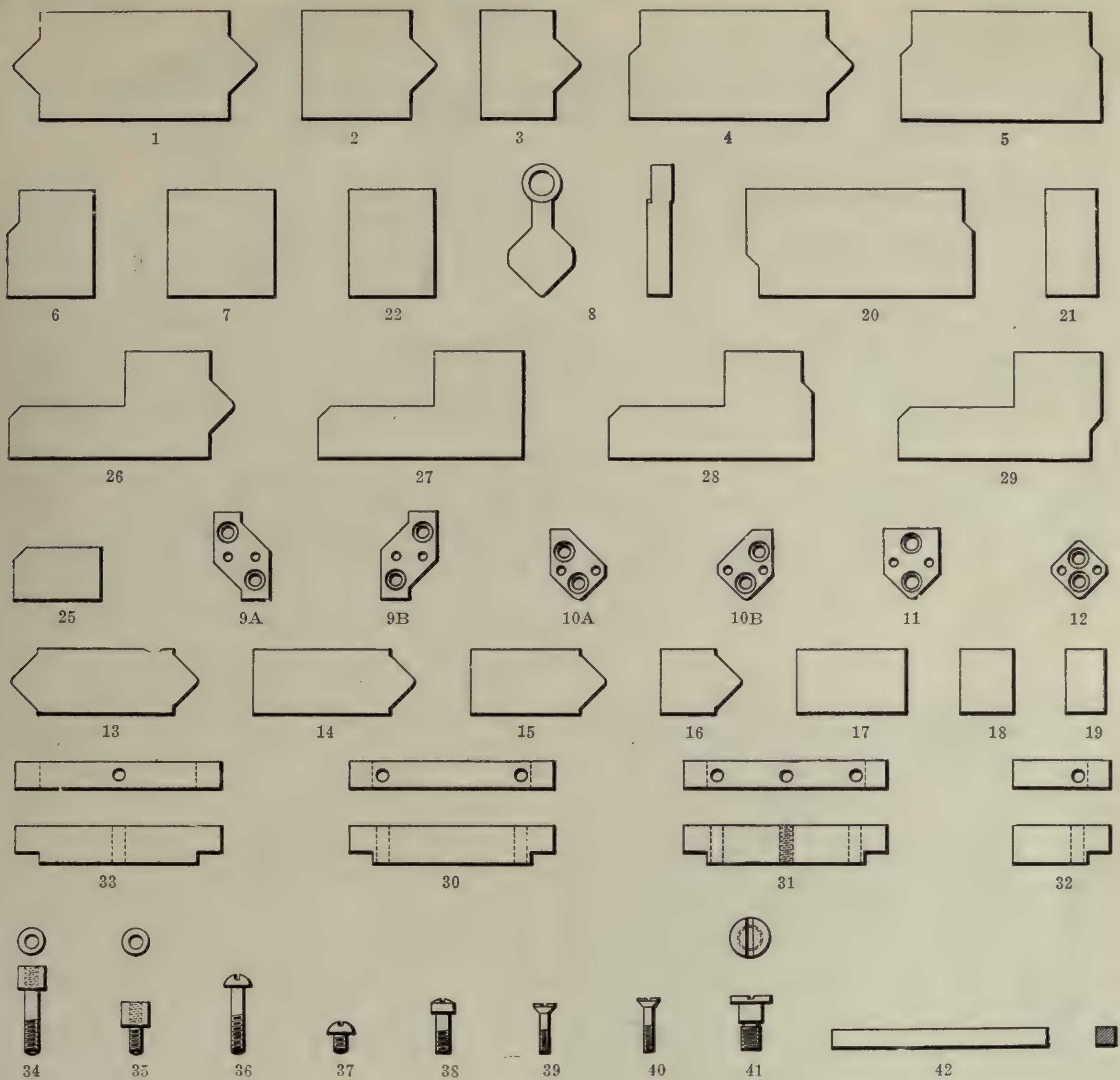
Figs. 853-854. Standard Interlocking Machine; Details of Latch Block.

Names of Parts of Standard Interlocking Machine; Figs. 851-854.

1	*Lever*	14	*Cap*
2	*Latch Handle*	15	*Back Tail Lever*
3	*Latch Rod*	16	*Front Tail Lever*
4	*Latch Shoe*	17	*Tappet Connecting Link*
5	*Latch Spring*	18	*Tappet Jaw*
6	*Latch Block*	19	*Tappet*
7	*Segment*	20	*Top Plate*
8	*Rocker*	21	*Locking Plate*
9	*Rocker Guide*	22	*Front Locking Guide*
10	*Back Girder*	23	*Locking Plate Strip*
11	*Front Girder*	24	*Back Locking*
12	*Machine Leg*	25	*Front Locking*
13	*Lever Shoe*	26	*Number Plate*



Figs. 855-858. Standard Locking in Place on Locking Plate, Representing a Portion of Fig. 902.



Figs. 859-900. Standard Locking Details.

Names of Parts of Standard Locking Details; Figs. 855-901.

1 *No. 1 Front Locking Dog*
2 *No. 2 Front Locking Dog*
3 *No. 3 Front Locking Dog*
4 *No. 4 Front Locking Dog*
5 *No. 5 Front Locking Dog*
6 *No. 6 Front Locking Dog*
7 *No. 7 Front Coupling Dog*
8 *No. 8 Special Swing Dog*
9A *No. 9A Tappet Piece*
9B *No. 9B Tappet Piece*
10A *No. 10A Tappet Piece*
10B *No. 10B Tappet Piece*
11 *No. 11 Tappet Piece*
12 *No. 12 Tappet Piece*
13 *No. 13 Back Locking Dog*
14 *No. 14 Back Locking Dog*
15 *No. 15 Back Locking Dog*
16 *No. 16 Back Locking Dog*
17 *No. 17 Back Coupling Dog*
18 *No. 18 Back Carrier Dog*
19 *No. 19 Back Carrier Dog*
20 *No. 20 Front Locking Dog*
21 *No. 21 Front Carrier Dog*
22 *No. 22 Front Locking Dog*
25 *No. 25 Front Locking Dog*
26 *No. 26 Front Locking Dog*
27 *No. 27 Front Locking Dog*
28 *No. 28 Front Locking Dog*
29 *No. 29 Front Locking Dog*
30 *No. 1 Front Locking Guide*
31 *No. 2 Front Locking Guide*
32 *No. 3 Front Locking Guide*
33 *No. 4 Front Locking Guide*
34 *Special Stud for Use with* 30
35 *Special Stud for Use with* 32
36 14/24 x 1⅛" *Round Head Machine Screw for Fastening Front Locking Guides* 30, 31, 32 *and* 33 *to Locking Plate*
37 14/24 x ⅜" *Machine Screw for Use with* 34 *and* 35
38 14/24 x ¾" *Filister Head Machine Screw for Fastening Tappet Pieces to Tappet*
39 10/32 x 13/16" *Flat Head Machine Screw Used for Fastening Front Lock Dogs, Couplers and Carriers to Locking Bar* 42.
40 10/32 x 15/16" *Flat Head Machine Screw Used for Fastening Back Locking Dogs, Couplers and Carriers to Locking Bar* 42
41 *Stud for Fastening and Pivoting Special Swing Dog* 8 *on Tappet*
42 *Locking Bar*

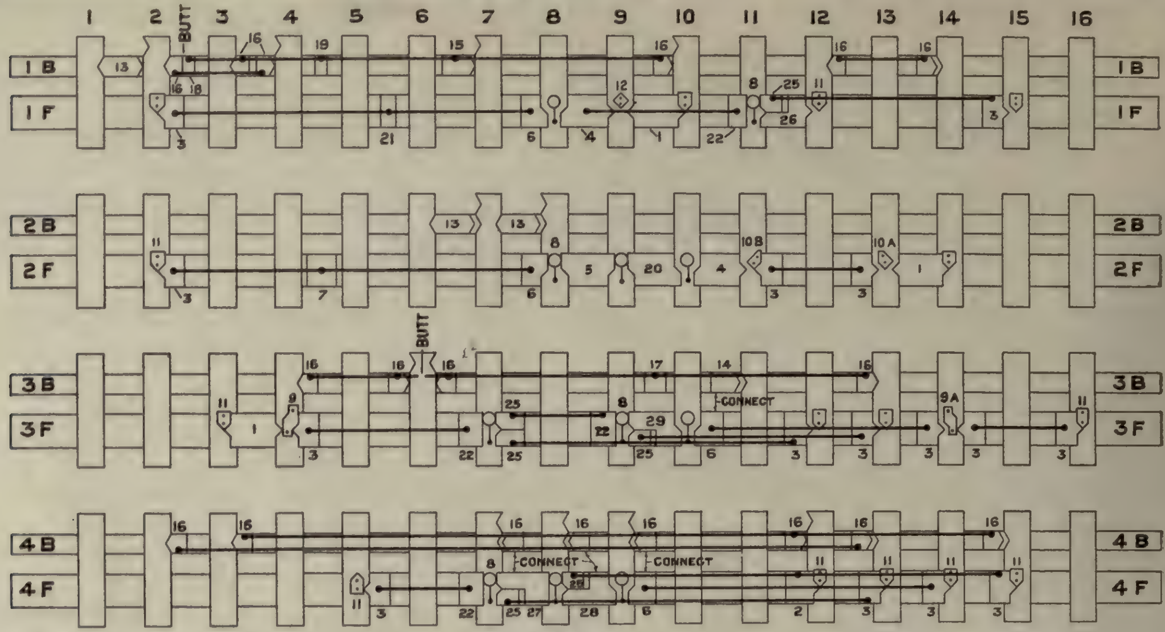


Fig. 901. Diagram of Standard Locking Details Assembled. A Portion of This Locking is Shown in Figs. 855-858.

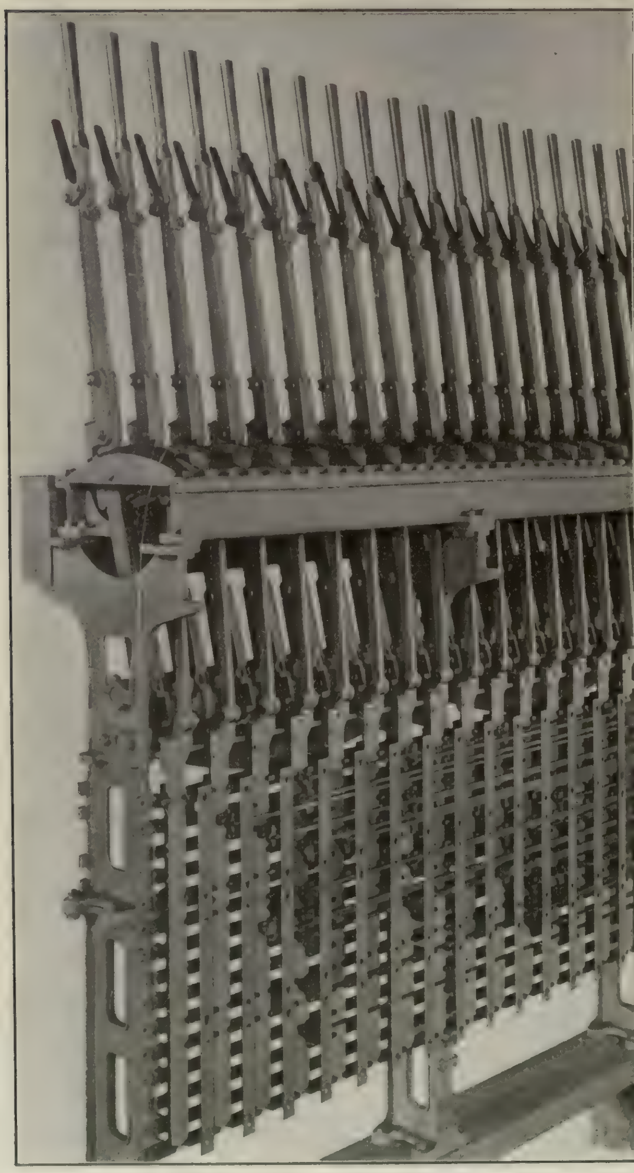


Fig. 902. Standard Interlocking Machine.

known as space 1, the next as space 2, and so on. Two tiers of locking may be placed in each space, the back tier being called the back locking and the front tier the front locking (see Sections A-A and B-B, Figs. 855-858), 4-F and 4-B (Section B-B) designate "The 4th space, front locking," and "The 4th space, back locking," respectively. This section also shows the relative positions of the front and back locking dogs and locking bars. It is possible to place three bars, side by side, in the space provided for the back locking bars, and five bars, side by side, in the space provided for the front locking bars (see Section A-A, showing two back locking bars and three front locking bars).

The mechanical construction of the locking is that of a bar or tappet locked by a dog moving at right angles to it and fitting in a notch cut in the edge of the tappet. For instance, the two adjacent levers 6 and 7, Fig. 901 (space 2B), are interlocked by the dog 13, which is made longer than the space between the two tappets. Thus one tappet will be free to move only when the dog slides into the notch cut in the other. Unless the notch in the second bar is in a position to allow the dog to be forced over, the tappet is locked and the lever cannot be moved. When the two levers to be interlocked are not next to each other, the dogs are connected together by a small locking bar 42 (Figs. 859-900), as shown between tappets 12 and 14 (space 1B), Figs. 855 and 901.

The dogs consist of tapered pieces of steel (1-6, 13-16, 20, and 25-29, Figs. 859-900). In the case of front locking, small lugs, known as tappet pieces (9A-12) are fastened to the tappets and the dogs strike against these as they would against the side of the notch in back locking. Special locking is employed as in the Saxby & Farmer machine. In this case the special consists of a swing dog 8 pivoted to the tappet. In other types of machines of this class, the special is usually a block sliding in a notch in the tappet.

If necessary a locking plate may also be placed on the opposite side of the machine legs beneath the front tail lever (16, Fig. 851), and tappets connected to the eye in the front end of the rocker.

A dog chart for a standard machine is shown in Figs. 741 and 746. For the sake of clearness the front and back locking for a given space is grouped as shown. Where front locking is shown (Fig. 746) the tappet pieces are shown only by lines representing their active faces.

THE JOHNSON INTERLOCKING MACHINE.

This machine (Figs. 903-932) differs from others of the vertical locking type in that the tappet moves upward when the lever is being reversed, instead of downward; also, the rocker is attached to a bracket which is rigidly connected to the lever and, therefore, moves with it, the connection between the rocker and tappet having only a vertical motion. The locking dogs, etc., used in this machine are similar to those used in the National machine (Figs. 936-1003), and to those used in the back locking of the Standard machine (Figs. 859-900). Preliminary latch locking is a feature of this machine.

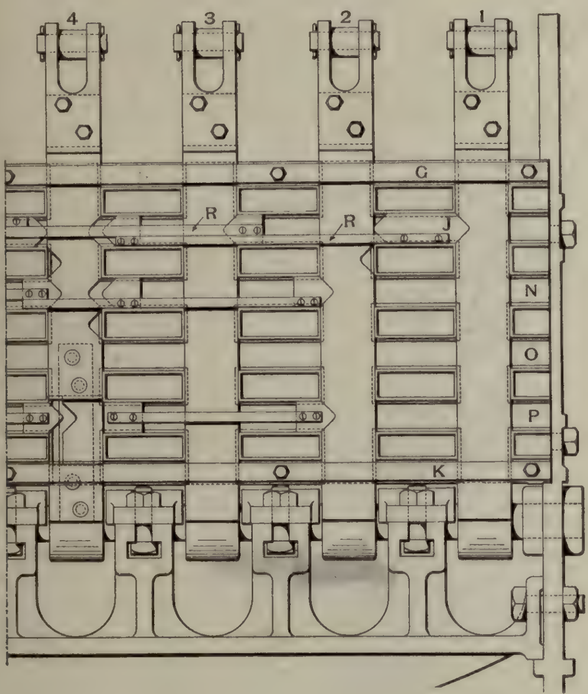
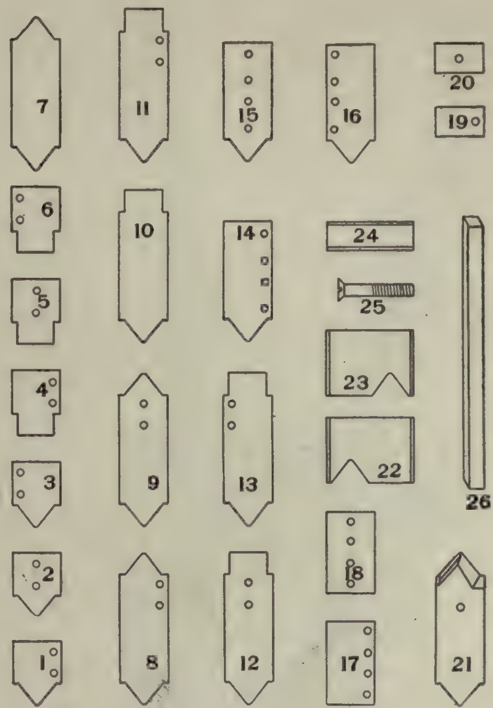


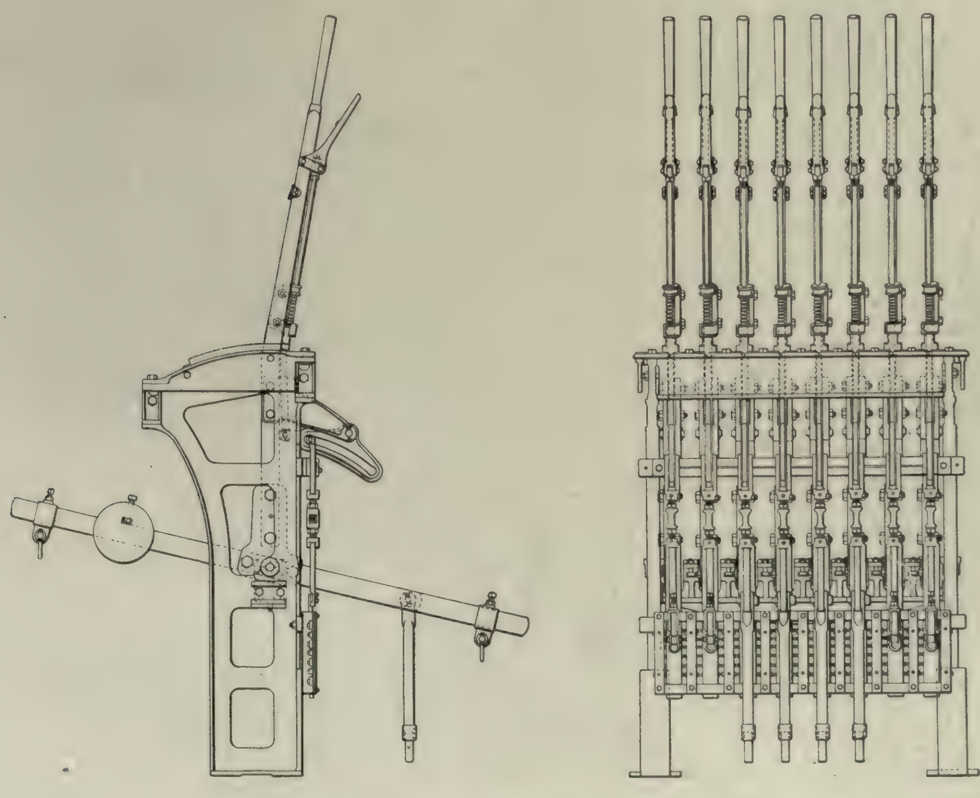
Fig. 903. Johnson Locking.



Figs. 904-929. Johnson Locking Details.

Names of Parts of Johnson Locking Details; Figs. 904-929.

1 *to* 21	*Locking Dogs*	24	*Spacing Strip*
22	*Special Locking Dog*	25	10/32" x ⅞" *Special Steel Screw for Locking Dogs*
23	*Locking Dog*	26	⅜" x ⅜" *Steel Locking Bar*



Figs. 930-931. Johnson Interlocking Machine.

THE NATIONAL INTERLOCKING MACHINE.

This machine (Figs. 933-1003) is somewhat similar in design and operation to the Standard; the lever, the latch handle and its connections, the rocker and the link connecting it to the tappet vary only slightly in design. Locking plates are often provided on both sides of the machine legs and operated as in the Standard machine. The type of locking used is similar to that used in the Johnson machine and to the back locking in the Standard, although a greater variety of dogs is necessary to secure the same results.

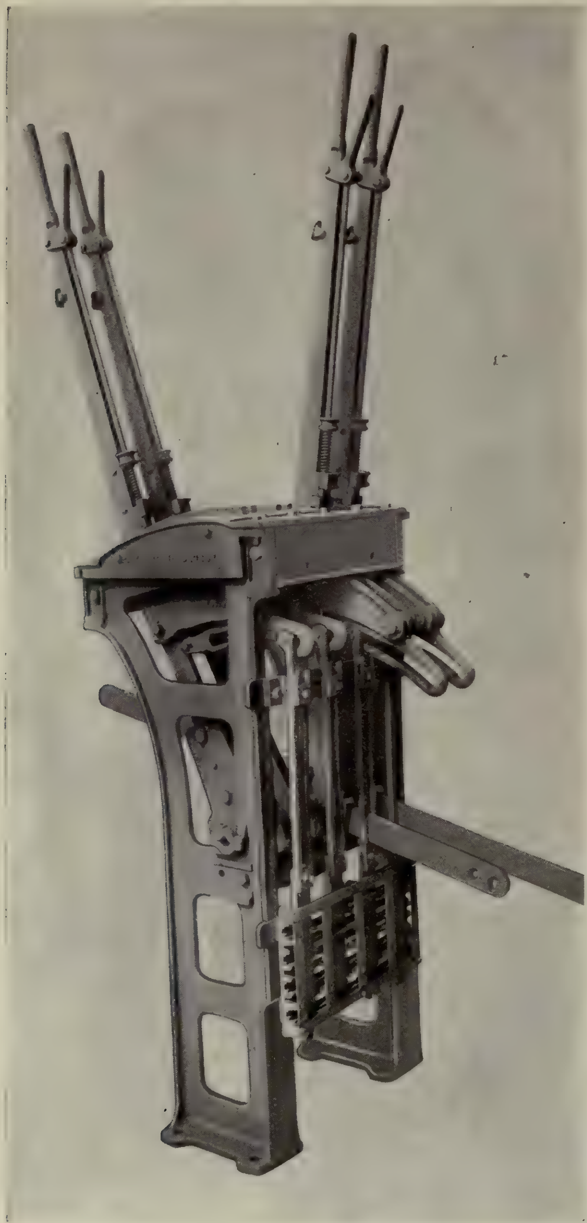


Fig. 932. The Johnson Interlocking Machine.

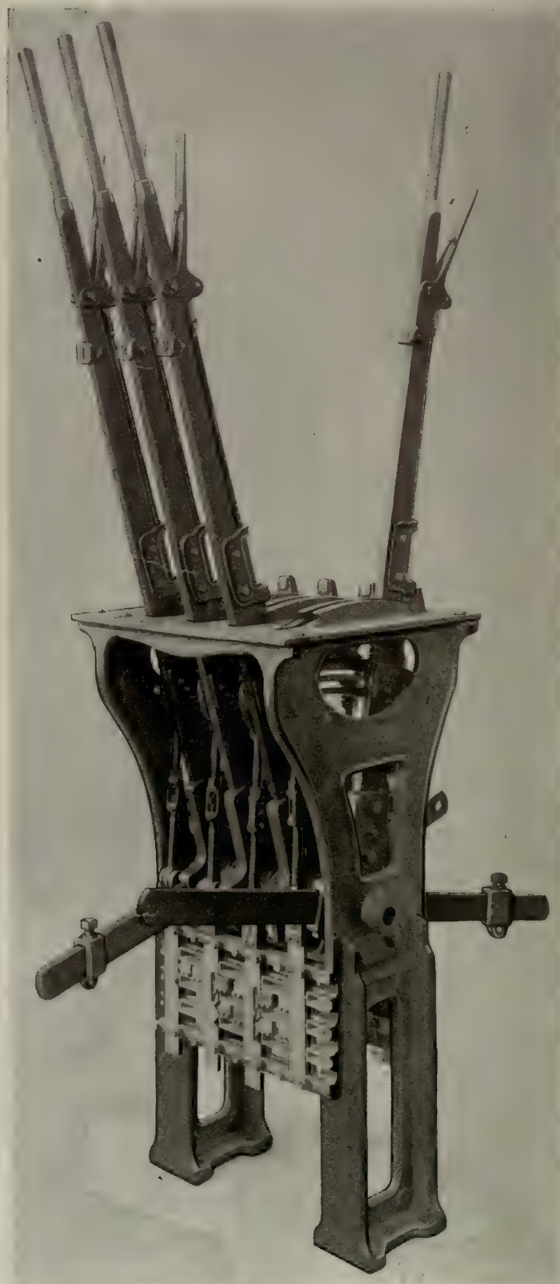
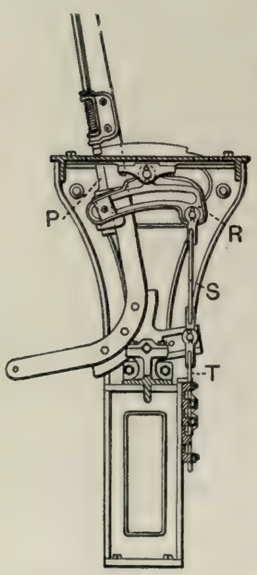


Fig. 933. The National Interlocking Machine.



Names of Parts; Fig. 934.

- S *Link*
- R *Rocker*
- T *Tappet*
- P *Latch Rod*

Fig. 934. The National Interlocking Machine, End Elevation.

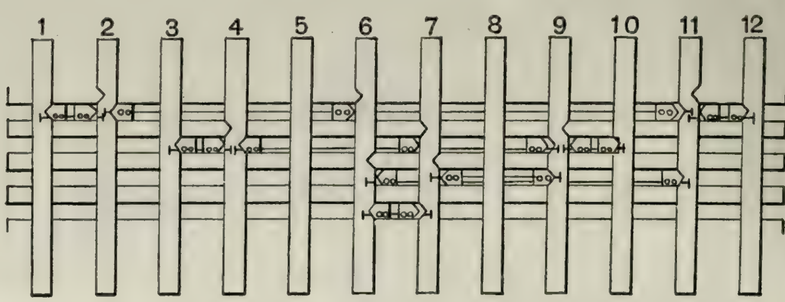
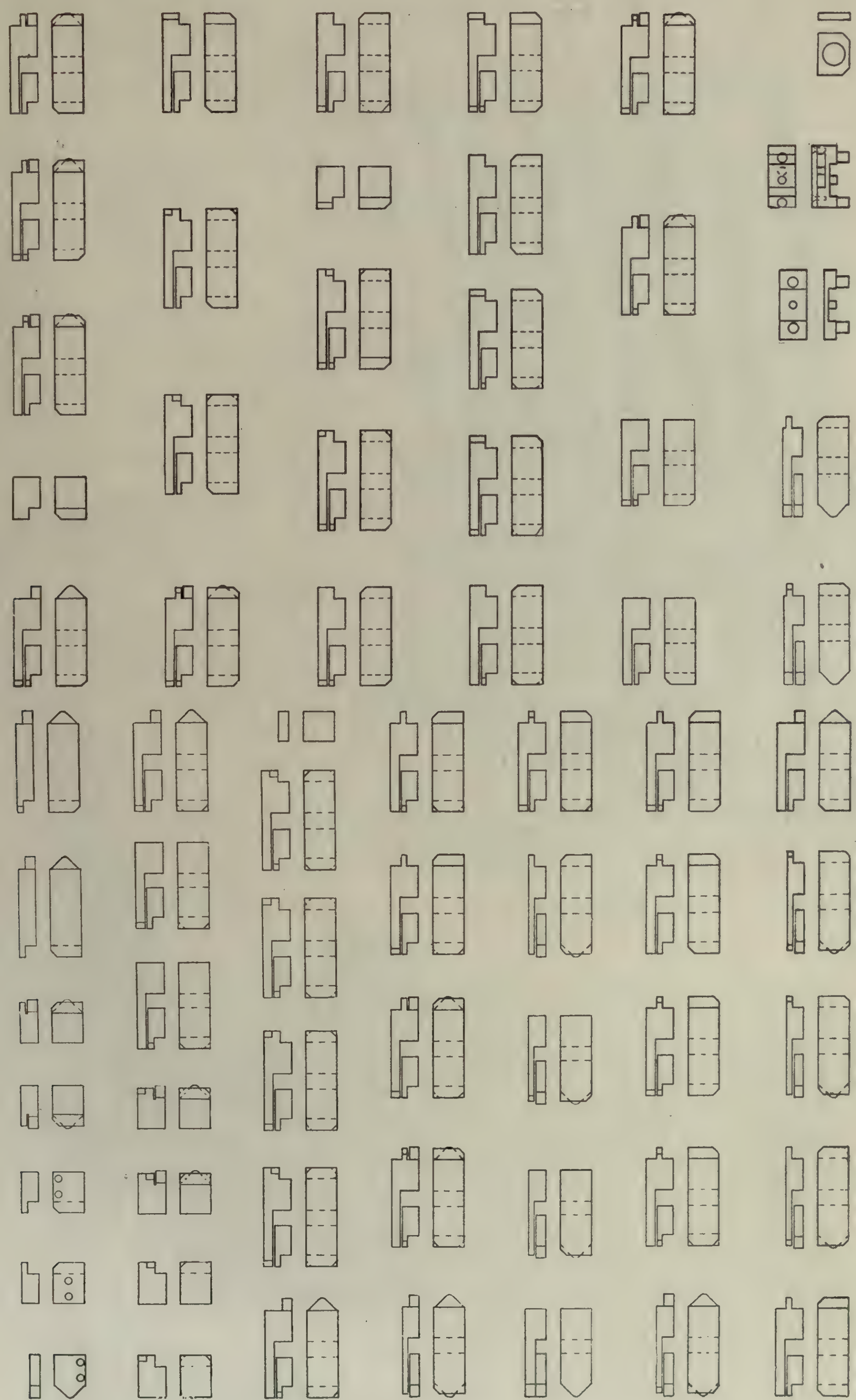


Fig. 935. Typical Diagram of Locking for a National Machine.



Figs. 936-1003. National Locking Details.

Fig. 1004. Dwarf Interlocking Machine. The Union Switch & Signal Company.

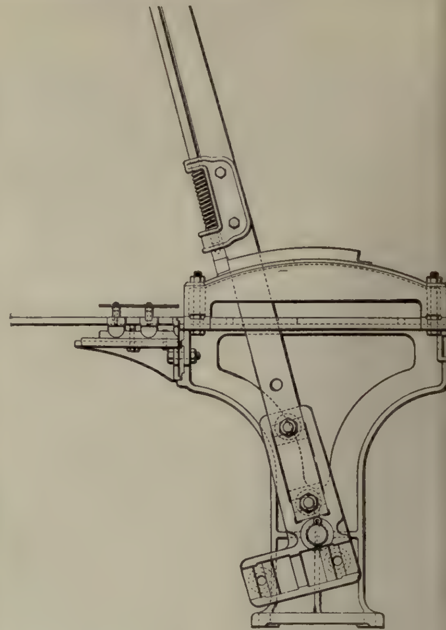


Fig. 1005. Style "C" Interlocking Machine.

DWARF INTERLOCKING MACHINE.

Fig. 1004 illustrates what is known as the Dwarf Interlocking Machine. Dwarf machines are designed for use at outlying switches and on elevated railroads, where they may be set on ties or on low platforms at track level. They can also be used instead of the Stevens or Style "C" machine, except where a vertical leadout is necessary. The dwarf machines are made without preliminary locking, and therefore are without the quadrants, universal links and locking bed attachments required where the refinement of latch-locking is necessary as in the types of machines shown on the preceding pages.

STEVENS INTERLOCKING MACHINE.

The Stevens interlocking machine is shown in Fig. 1006. It is designed to work and control a small number of switches and signals at points where the space for installing a machine is limited or where it is found advantageous to control a number of yard switches from a central point. It can be operated on the ground level with horizontal connections, or can be set on a platform and be vertically connected. This type of machine is made without preliminary latch locking.

STYLE "C" INTERLOCKING MACHINE.

The Style "C" interlocking machine, shown in Fig. 1005, is similar in design to the Stevens and is also intended for use where it is desired to control a number of units in a yard as from a location at grade where it is not always feasible to construct a tower.

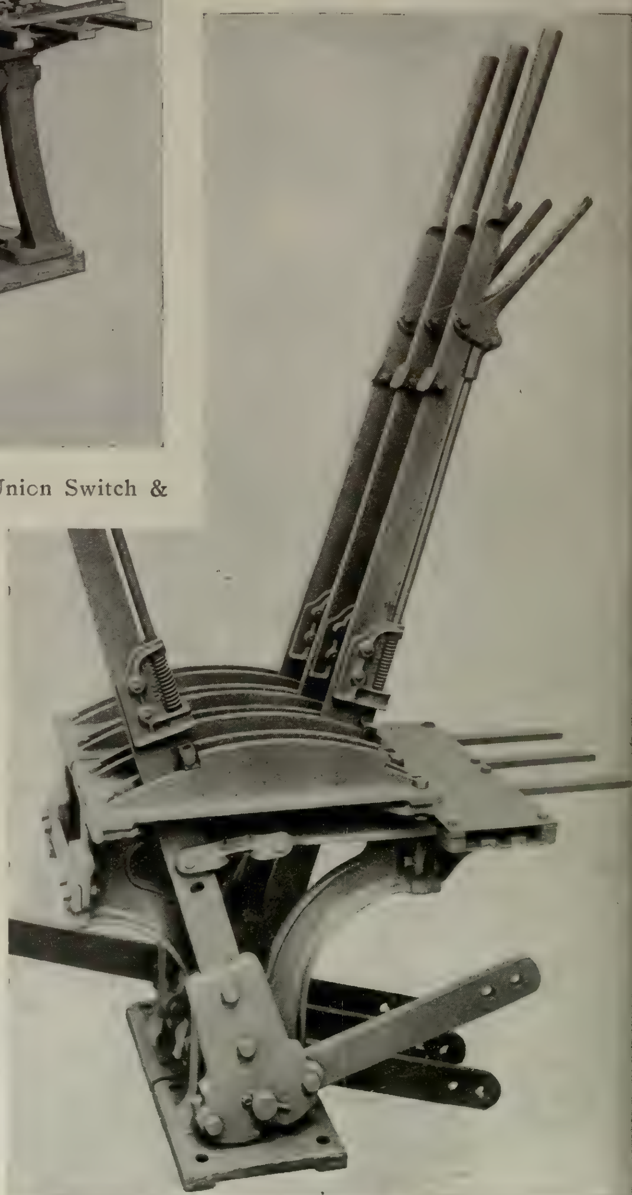
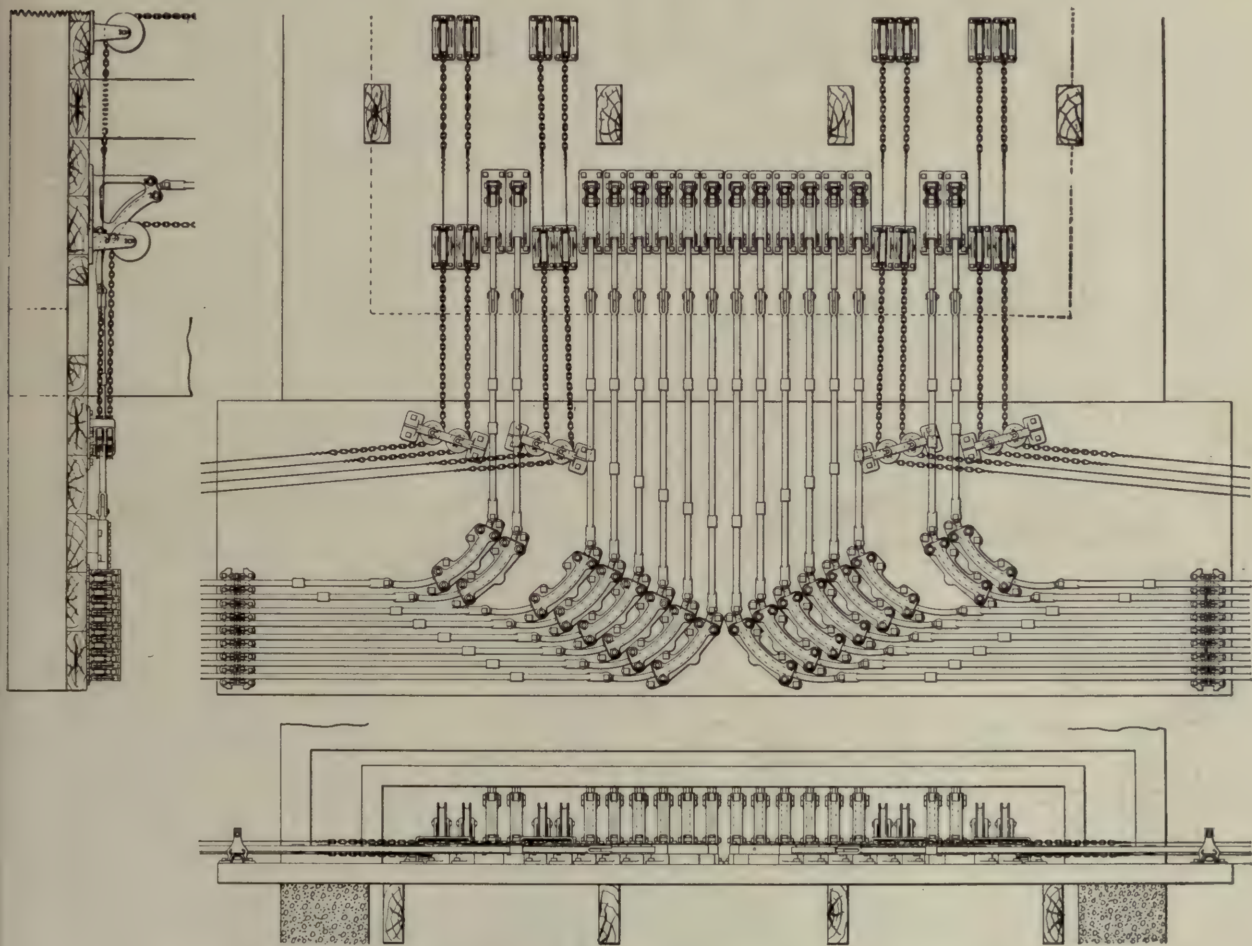


Fig. 1006. The Stevens Interlocking Machine.

MECHANICAL INTERLOCKING PARTS AND DETAILS OF CONSTRUCTION

LEADOUTS.

The leadout or arrangement of apparatus by which the operating connections are carried from the machine out of the tower consists of a foundation or platform forming an extension of the tower floor and the leadout devices which are mounted thereon. These may consist of deflecting bars, Figs. 1007-1009, rocker shafts, 1010-1015, box cranks, 1016-1020, or any combination of the three. The rockers may be inverted where clearances demand (Fig. 1010). Rocker shafts are made of hexagonal or square steel bars mounted in bearings (Figs. 1283-1285). They carry arms to which the vertical rods and pipe lines are attached. A box crank is a frame in which a number of cranks are mounted (Figs. 1152-1158). A box crank leadout requires more space than a rocker shaft leadout, but is more accessible. Where box cranks are used the vertical rods must be attached to vertical cranks.



Figs. 1007-1009. Layout Showing Deflecting Bar Leadout.

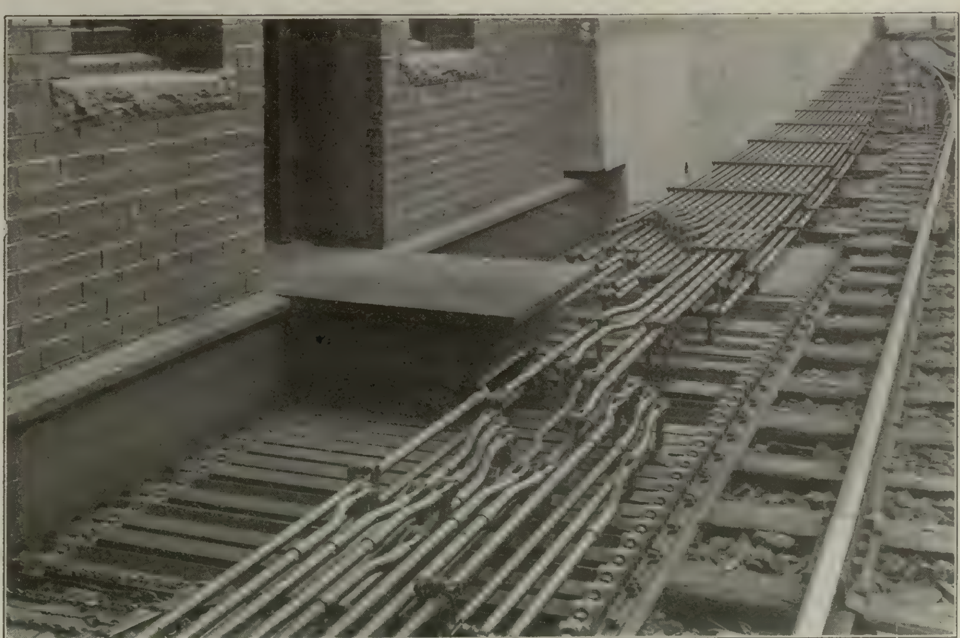
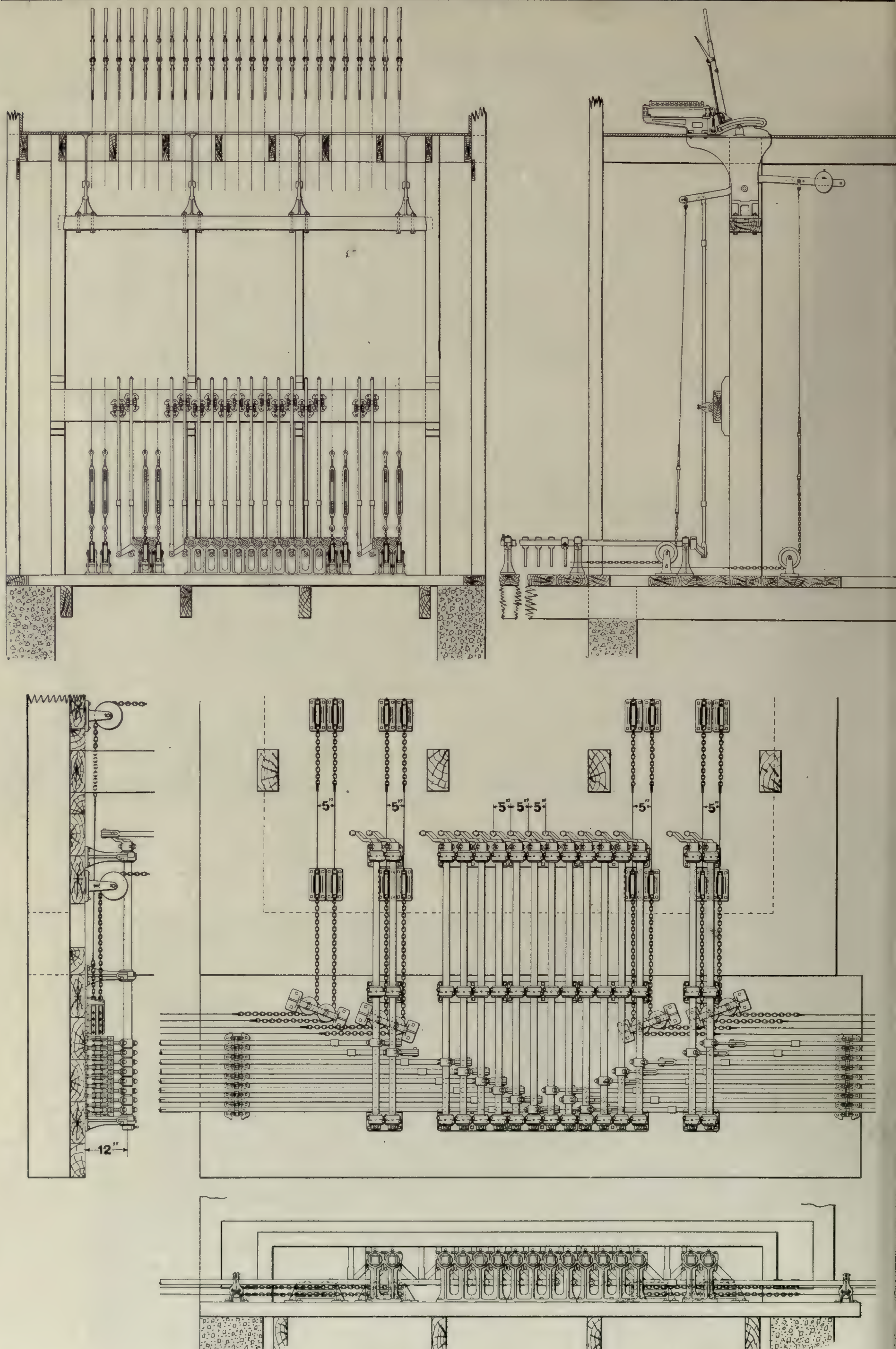
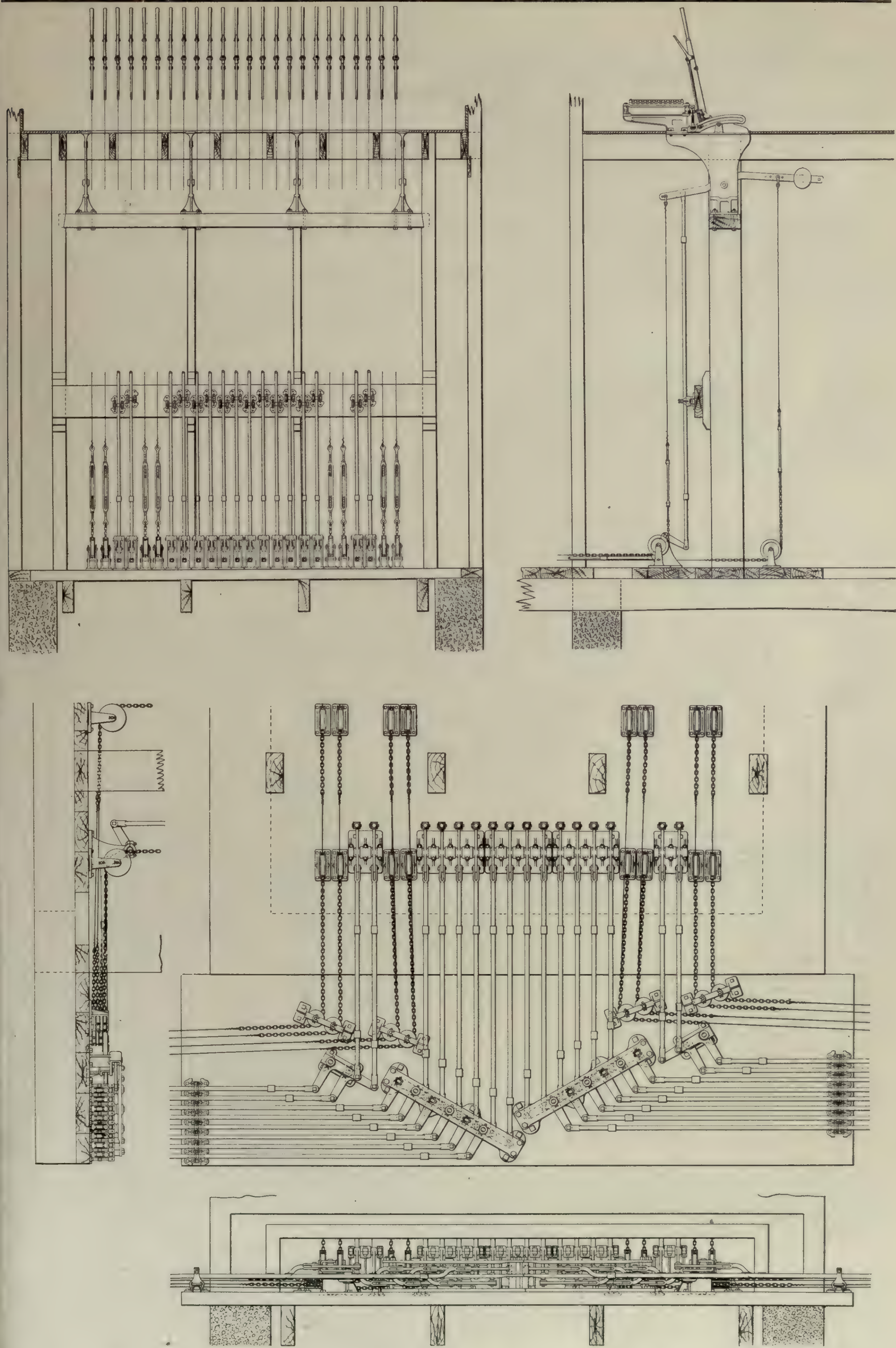


Fig. 1010. Inverted Rocker Shaft Leadout and Double-Deck Pipe Line. Delaware, Lackawana & Western.



Figs. 1011-1015. Layout Showing Saxby & Farmer Interlocking Machine in Cabin, Rocker Shaft and Box Wheel Leadout.



Figs. 1016-1020. Layout Showing Saxby & Farmer Interlocking Machine in Cabin, with Box Crank and Box Wheel Leadout.

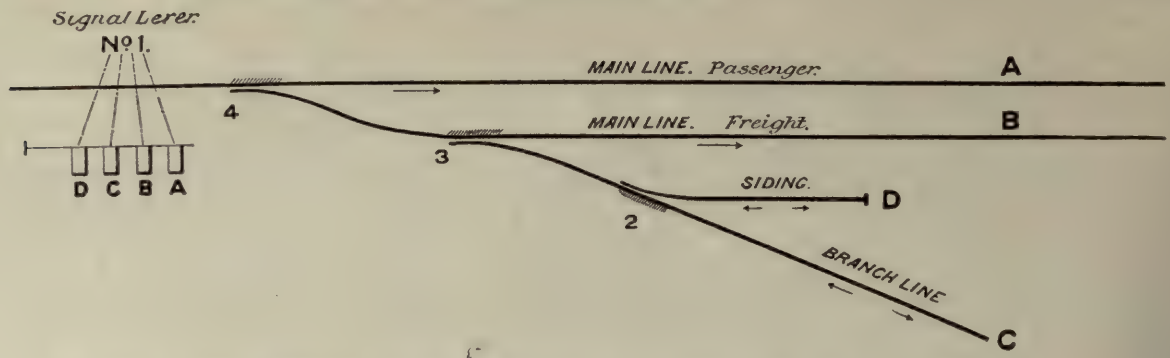
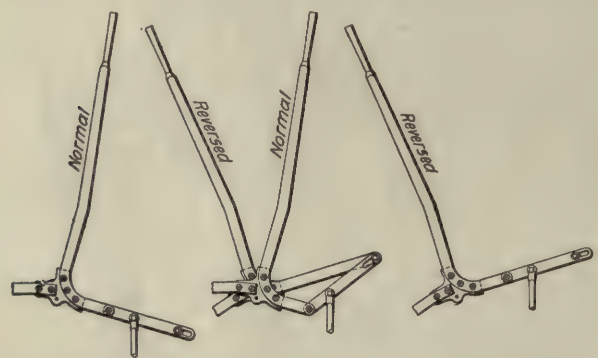


Fig. 1021. Track Diagram Showing Application of Selector Illustrated in Fig. 1025.

TWO LEVERS OPERATING A THREE-POSITION SIGNAL.

Figs. 1022-1024 show how a three-position signal may be operated by two levers and one pipe line. A floating lever is introduced between the two machine tail levers, and to this the pipe line is attached. The illustration shows the position of the apparatus corresponding to each position of the signal.



Figs. 1022-1024. Method of Operating a Three-Position Signal from Two Levers. Baltimore & Ohio.

SELECTORS.

Several signals may be operated from one lever by means of selectors, the signal cleared depending upon the position of the various switches. Figs. 1025 and 1021 show a perspective view of a four-hook tower selector and a track diagram showing its application. The signals are wire connected. The pull wires are attached to hooks in the selector, all of which, except that to arm A, are normally disengaged from the dog at the end of the rod operated by lever No. 1. When switch 4 is reversed A is disengaged and B is engaged by the action of the cam on the shaft actuated by lever 4. When 3 and 4 are both reversed B is disengaged and C engaged. Reversal of 2, 3 and 4 disengages C and engages D. A similar arrangement can be used with pipe connected signals.

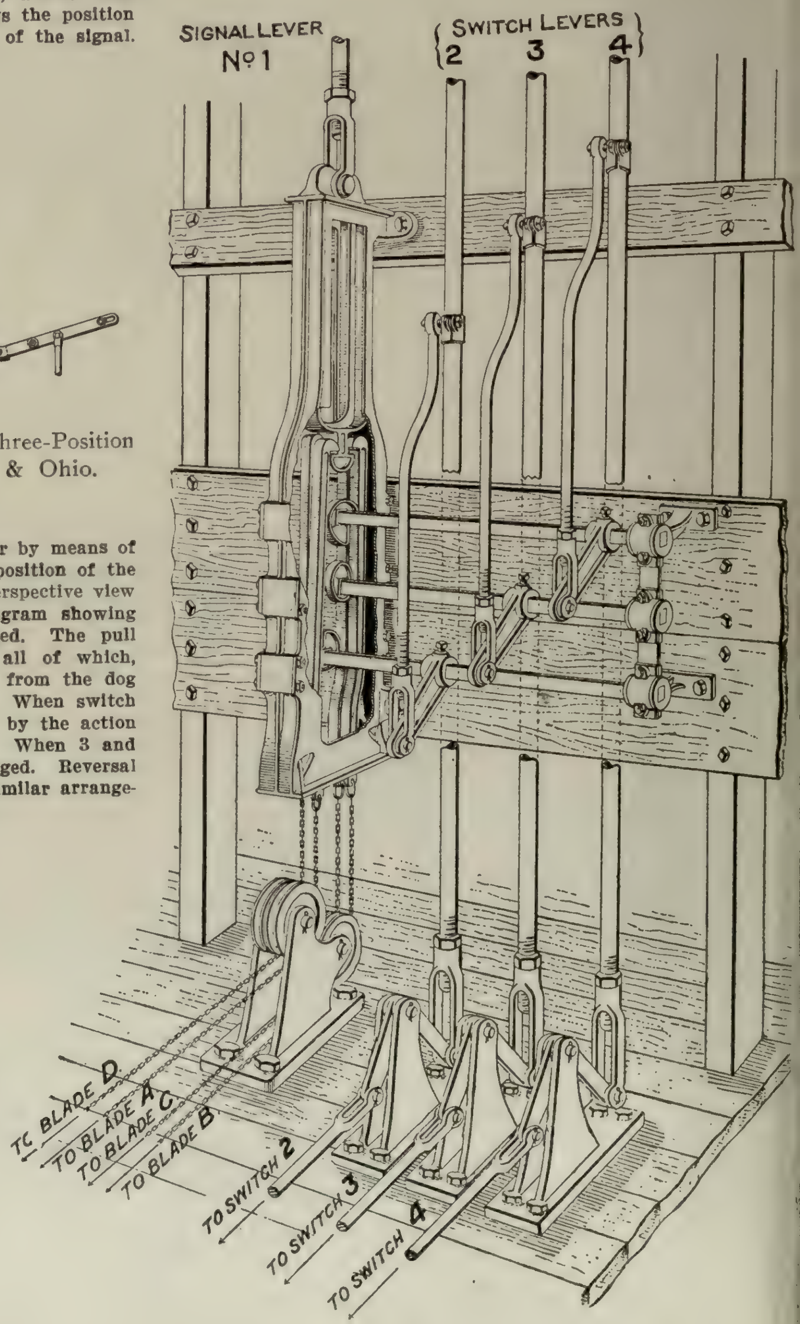


Fig. 1025. Wire Connected Cabin Hook Selector. The Union Switch & Signal Company.

PIPES AND COUPLINGS.

The connections between the lever of the interlocking machine and its function, through which the motion is imparted, consist of one in. iron pipe or No. 9 gage steel wire. Wire is used for signals only. Lengths of pipe are joined together or to jaws by coupling sleeves and rivets through iron plugs or through the tang end of the jaw. Thus a rigid joint is secured which does not depend on the threads. Various pipe and rod connections and adjustments are shown in Figs. 1026-1024 and 1047-1121). The butt or "stub" ends are provided for welding to solid rods.

Following are R. S. A. specifications for one-inch pipe and couplings:

PIPE.—1. Pipe must be soft steel straight, tough and uniform in quality; free from cinder pockets, blisters, burns and other injurious flaws. Must be hot galvanized inside and outside, unwiped.

accepted weighing less than 1.63 pounds per foot, weight of coupling not included.

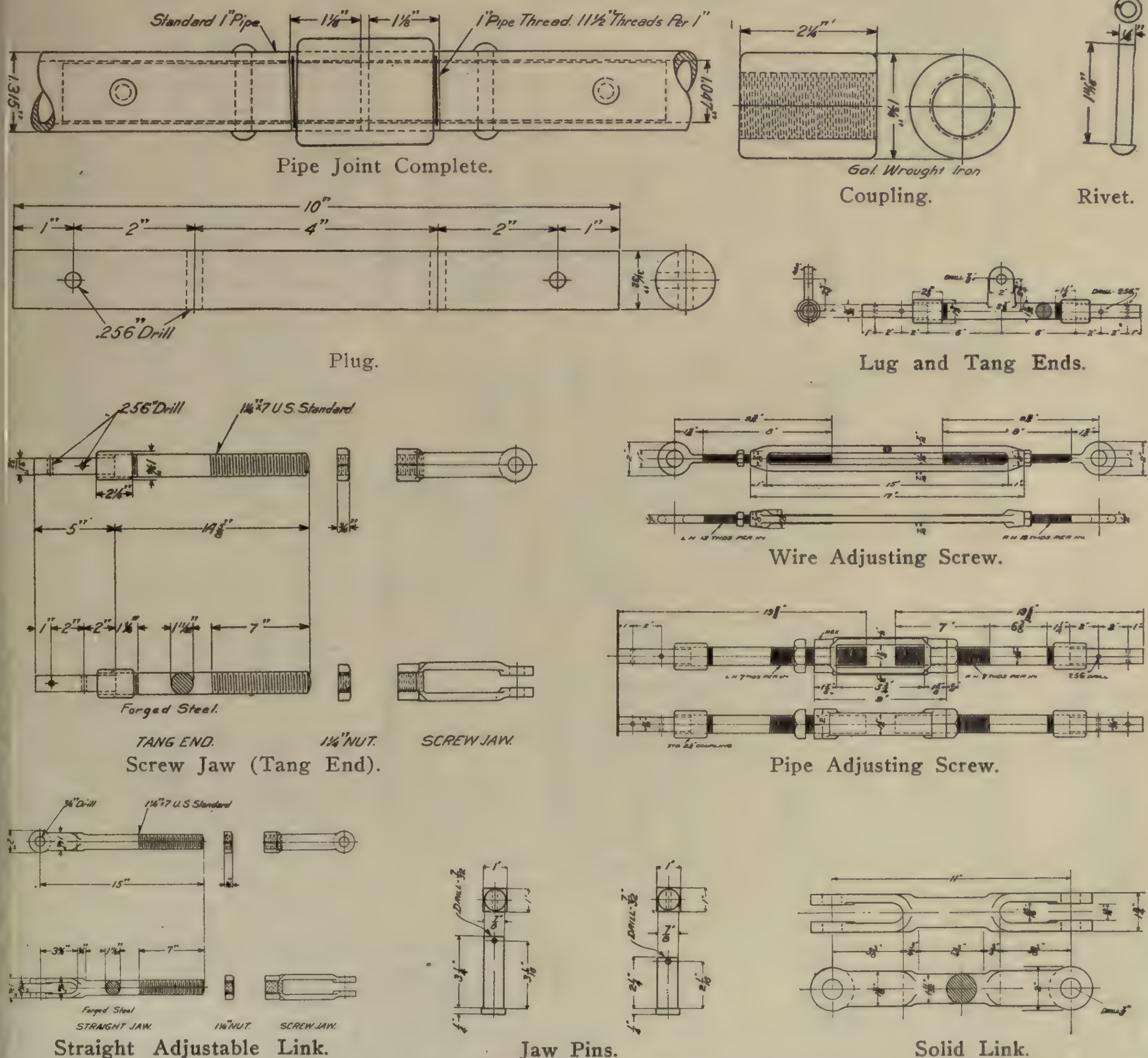
5. The outside diameter of pipe must conform to Briggs' Standard. Any pipe enough less than 1.31 inches in diameter to result in flat thread will be rejected.

6. The manufacturer shall furnish all necessary facilities for making tests and the tests shall be made at the mill.

7. Inside diameter of all pipe must be large enough to receive a hardened steel plug of 63-64 inch diameter for a length of six inches.

8. Not more than one per cent. of pipe less than 15 feet long will be accepted, lengths of 17 feet and over being preferred.

9. The ends of pipe must be cut square and drilled for two ¼-inch rivets on one end only; first rivet hole shall be drilled two inches from the end and the second two inches from this and at right angles to it.



Figs. 1026-1046. Railway Signal Association Standards.

2. The tensile strength, limit of elasticity and ductility shall be determined from a test piece cut from finished pipe.

3. The pipe shall have a tensile strength of not less than 52,000 pounds per square inch, and an elastic limit of not less than 30,000 pounds per square inch, and an elongation of not less than 18 per cent. in a measured length of eight inches. All pipe must stand a test of 600 pounds per square inch internal hydrostatic pressure without leak.

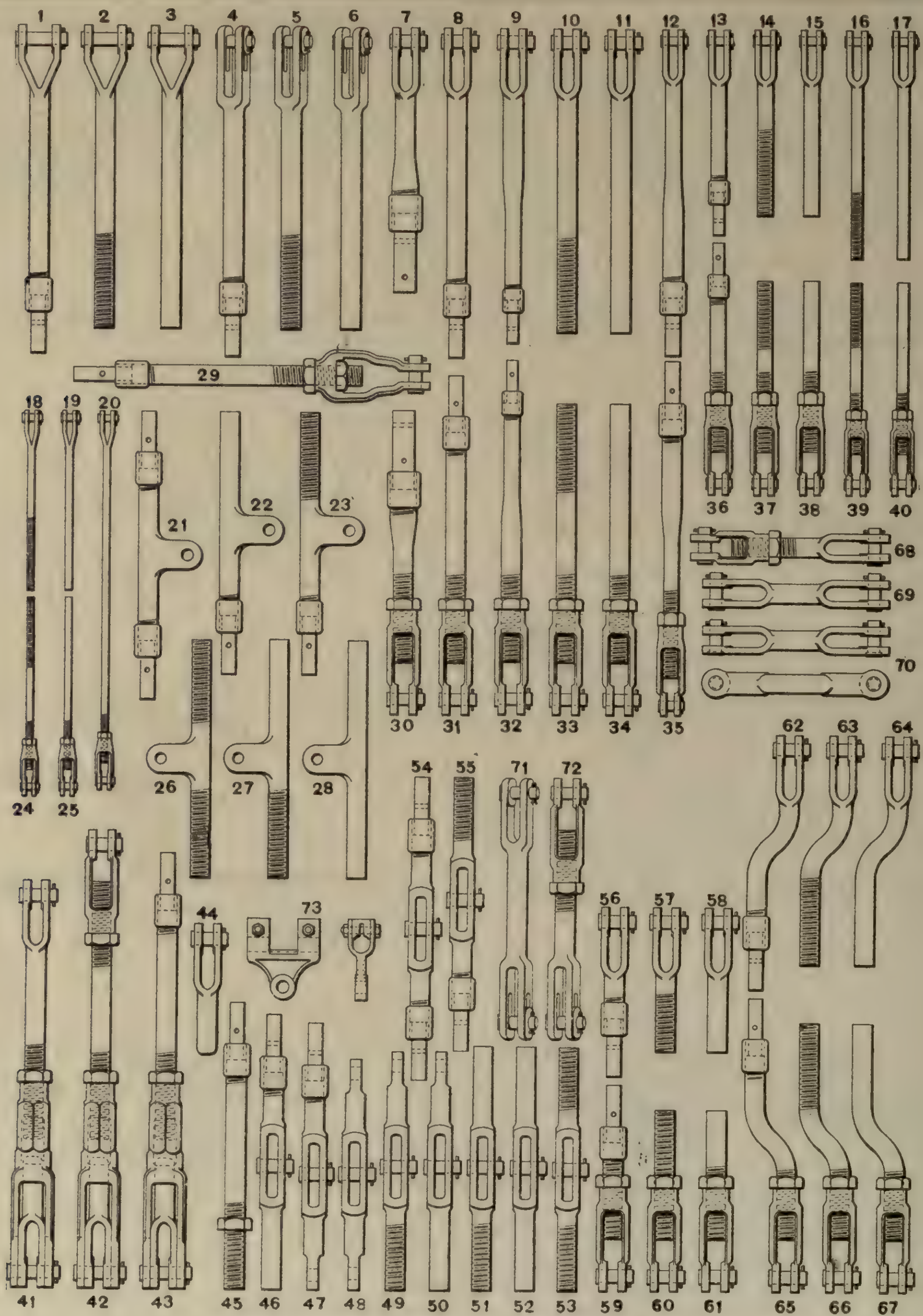
A piece of pipe one foot long will be selected at random and be subjected to a flattening test by hammering the piece until the opposite sides are within twice the thickness of the wall from each other; the piece shall show no cracks in the steel except at the weld.

4. The weight of one foot of one inch pipe before galvanizing should be 1.71 pounds, and in no case will pipe be

10. Each length of pipe shall have a thread 1⅛-inch long, ⅝-inch total taper per foot, 11½ slightly round top and bottom "V" threads to the inch. The threaded portion of the pipe shall be of such diameter as to admit the coupling to be screwed on five turns by hand, with a permissible variation of one turn either way.

COUPLINGS.—Pipe couplings must be galvanized, must be 2¼ inches long and 1¾ inches outside diameter, of wrought iron, free from defects, faced at ends, tapped straight through, pitch diameter of thread to be such as to fit pipe as per section 10 above, 1.26 inches, varying not more than .003 of an inch.

PLUGS.—Plugs must be merchant bar steel, 10 inches long, 31-32 inch in diameter, drilled for four ¼-inch rivets with drill .256:

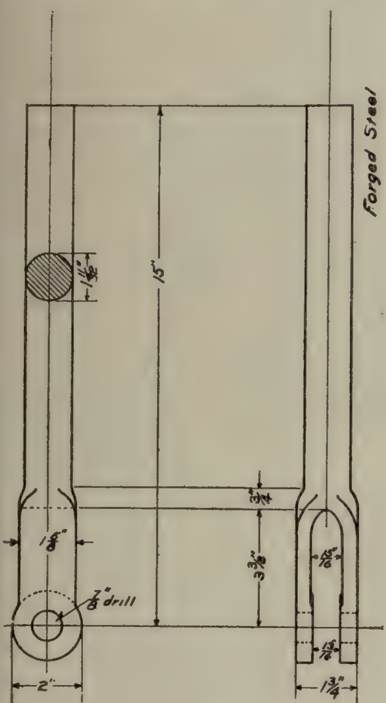


Figs. 1047-1121. Jaws, Pipe Lugs, and Links.

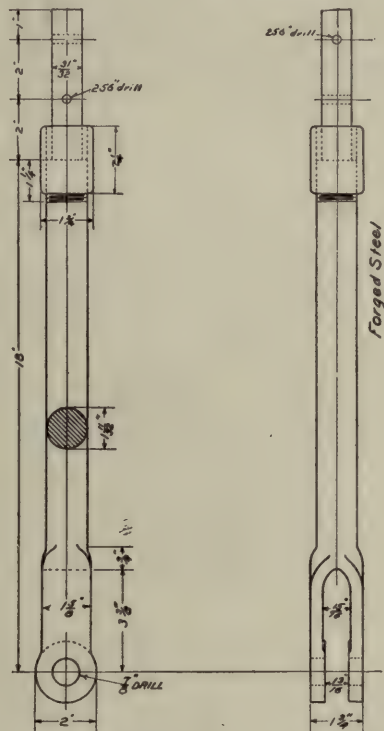
Names of Parts; Figs. 1047-1121.

1 *Tang End Wide Jaw, 1¼-in.*
2 *Threaded End Wide Jaw, 1¼-in.*
3 *Butt End Wide Jaw, 1¼-in.*
4 *Tang End Slotted Jaw, 1¼-in.*
5 *Threaded End Slotted Jaw, 1¼-in.*
6 *Butt End Slotted Jaw, 1¼-in.*
7 *Tang End Transition Jaw, 1¼-in. to 1-in.*
8 *Tang End Jaw, 1¼-in.*
9 *Tang End Transition Jaw, 1-in. to 1¼-in.*
10 *Threaded End Jaw, 1¼-in.*
11 *Butt End Jaw, 1¼-in.*
12 *Tang End Transition Jaw, 1¼-in. to 1-in.*
13 *Tang End Jaw, 1-in.*
14 *Threaded End Jaw, 1-in.*
15 *Butt End Jaw, 1-in.*
16 *Threaded End Jaw, ¾-in.*
17 *Butt End Jaw, ¾-in.*
18 *Threaded Up and Down Rod with Jaw, ½-in.*
19 *Butt End Up and Down Rod with Jaw, ½-in.*
20 *Up and Down Rod with Plain and Screw Jaw, ½-in.*
21 *Tang End Lug*
22 *Butt and Tang End Lug*
23 *Threaded and Tang End Lug*
24 *Threaded Up and Down Rod with Screw Jaw, ½-in.*
25 *Butt End Up and Down Rod with Screw Jaw, ½-in.*
26 *Threaded End Lug*
27 *Butt and Threaded End Lug*
28 *Butt End Lug*
29 *Tang End Clevis Nut, 1¼-in.*
30 *Tang End Transition Screw Jaw, 1¼-in. to 1-in.*
31 *Tang End Screw Jaw, 1¼-in.*
32 *Tang End Transition Screw Jaw, 1-in. to 1¼-in.*
33 *Threaded End Screw Jaw, 1¼-in.*
34 *Butt End Screw Jaw, 1¼-in.*
35 *Tang End Transition Screw Jaw, 1¼-in. to 1-in.*
36 *Tang End Screw Jaw, 1-in.*
37 *Threaded End Screw Jaw, 1-in.*
38 *Butt End Screw Jaw, 1-in.*
39 *Threaded End Screw Jaw, ¾-in.*
40 *Butt End Screw Jaw, ¾-in.*
41 *Gain Stroke Jaw with Plain Jaw, 1¼-in.*
42 *Gain Stroke Jaw with Screw Jaw, 1¼-in.*
43 *Tang End Stroke Jaw, 1¼-in.*
44 *Butt End Jaw, 1¼-in.*
45 *Tang End Threaded Rod, 1¼-in.*
46 *Tang and Butt End Double Jaw, 1¼-in.*
47 *Tang End Double Jaw with Eye, 1¼-in.*
48 *Double Jaw with Two Eyes, 1¼-in.*

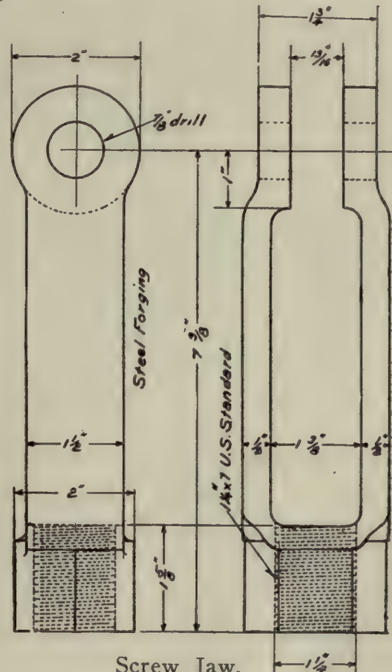
49 *Threaded End Double Jaw with Eye, 1¼-in.*
50 *Butt End Double Jaw with Eye, 1¼-in.*
51 *Butt and Threaded End Double Jaw, 1¼-in.*
52 *Butt End Double Jaw, 1¼-in.*
53 *Threaded End Double Jaw, 1¼-in.*
54 *Tang End Double Jaw, 1¼-in.*
55 *Tang and Threaded End Double Jaw, 1¼-in.*
56 *Tang End Jaw, 1¼-in.*
57 *Threaded End Jaw, 1¼-in.*
58 *Butt End Jaw, 1¼-in.*
59 *Tang End Screw Jaw, 1¼-in.*
60 *Threaded End Screw Jaw, 1¼-in.*
61 *Butt End Screw Jaw, 1¼-in.*
62 *Tang End Offset Jaw, 1¼-in.*
63 *Threaded End Offset Jaw, 1¼-in.*
64 *Butt End Offset Jaw, 1¼-in.*
65 *Tang End Offset Screw Jaw, 1¼-in.*
66 *Threaded End Offset Screw Jaw, 1¼-in.*
67 *Butt End Offset Screw Jaw, 1¼-in.*
68 *Adjustable Link, 1¼-in.*
69 *Solid Link, 1¼-in.*
70 *Solid Link, 1¼-in.*
71 *Solid Link with Slotted Jaw, 1¼-in.*
72 *Adjustable Link with Slotted Jaw, 1¼-in.*
73 *Clamp Pipe Lug*



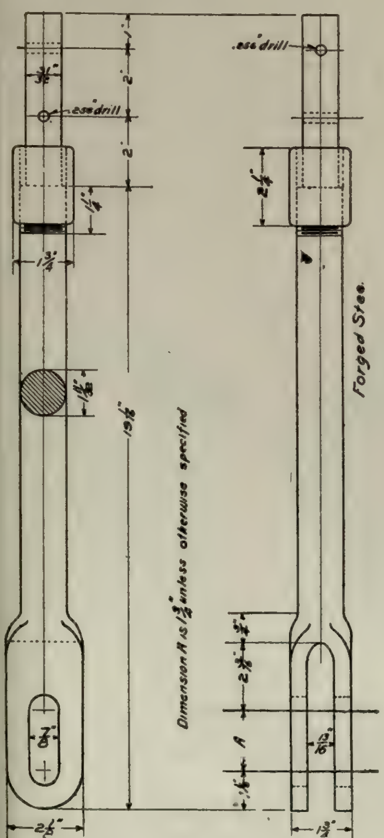
Solid Jaw (Butt End).



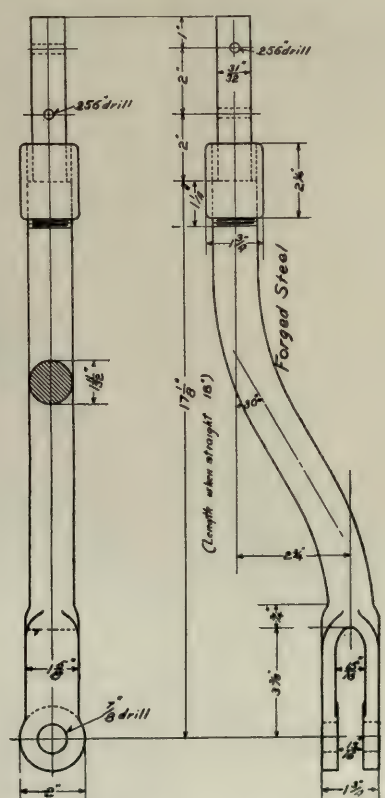
Straight Solid Jaw (Tang End).



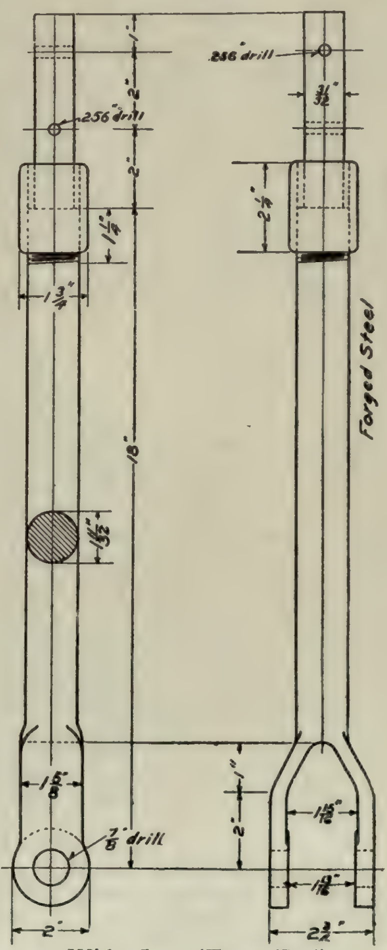
Screw Jaw.



Slotted Jaw (Tang End).



Offset Solid Jaw (Tang End).



Wide Jaw (Tang End).

Figs. 1122-1133. Railway Signal Association Standard Jaws.

R. S. A. SPECIFICATIONS FOR GRAY IRON CASTINGS.

1. Gray iron castings must be of good sound iron, free from flaws, blow holes, flues, cold shuts, or shrinkage cracks. They must conform to dimensions shown on drawings and must not exceed the specified weight, when weight is specified.

2. Castings having any section less than ½ inch thick shall be known as light castings.

Castings in which no section is less than two inches thick shall be known as heavy castings.

Medium castings are those not included in the above.

Light castings, sulphur not over 0.08 per cent.; medium castings, sulphur not over 0.10 per cent.; heavy castings, sulphur not over 0.12 per cent.

Transverse Test. The breaking strength of the arbitration bar under transverse load shall not be under light castings, 2500 lbs.; medium castings, 2900 lbs.; heavy castings, 3300 lbs.; with load applied at center and points of support 12 inches apart.

2. Manufacturers will submit, for approval, a sample casting from each pattern, when so requested.

3. When shown on the blue print, each casting must have one or more test lugs. The shape, size and number must be as specified, although the location will be left to the option of the manufacturer. The test lugs, when broken off, shall show tough and strong material.

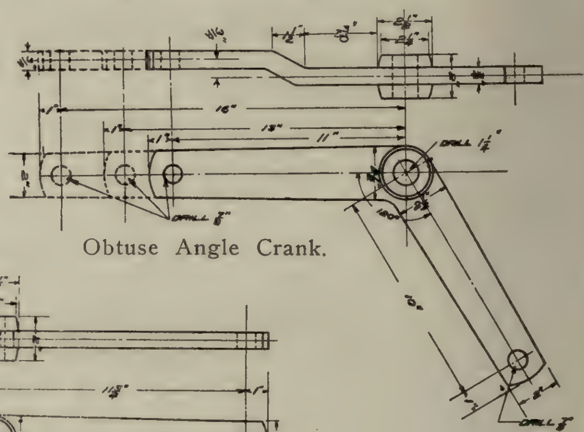
R. S. A. SPECIFICATIONS FOR MACHINERY STEEL.

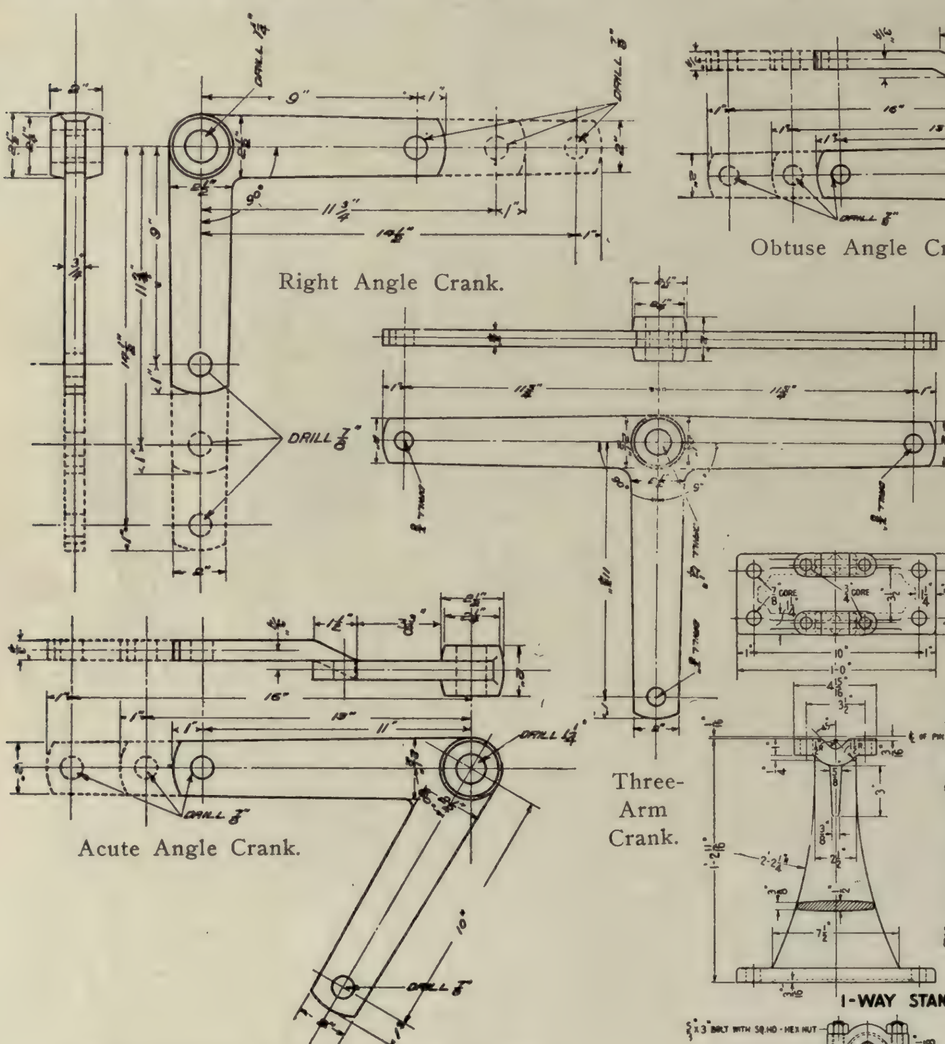
1. All sections must be true to size, free from cracks, flaws and defects of all kinds.

2. When subjected to a tensile test the steel must show: Tensile strength per square inch 48,000 to 58,000 lbs. Elongation in eight inches, not less than 25 per cent.

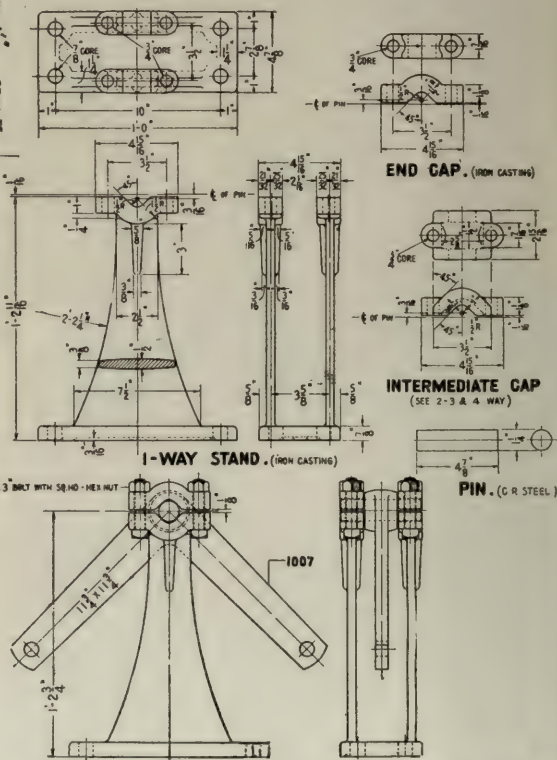
3. Phosphorous not to exceed 0.1 per cent.; sulphur not to exceed 0.065 per cent.

4. When subjected to a bending test, either hot or cold, the





Figs. 1134-1138. R. S. A. Standard Cranks.



Figs. 1139-1145. R. S. A. One-Way Vertical Crank Stand.

3. The manufacturer's pattern number must appear on each casting and be so located that it will not wear off or interfere with the fitting of other parts to the casting.

4. Castings will be inspected at the shops of the manufacturer, and those which fail to meet the above requirements will be rejected. Test of test specimens may be made at the place of manufacture, the manufacturer to furnish suitable apparatus to make the test without expense to the purchaser; or these tests may be made at destination, if the purchaser so desires, in which case the foundry will furnish two arbitration bars for each melt used in filling the shipment.

A blue print showing the arbitration bar and its mold will be supplied to those filling orders for gray iron castings for the purchaser, upon request.

R. S. A. SPECIFICATIONS FOR MALLEABLE IRON CASTINGS.

1. Malleable iron castings must be well rattled, clean and reasonably free from flaws or shrinkage cracks. They must conform to the dimensions specified and must not exceed the specified weight when a weight is given.

steel must bend double over a diameter equal to its own thickness without showing any fracture.

5. The results of the chemical analysis made at the steel works of each melt used to fill the order must be furnished to the purchaser's inspector when requested.

Mild steel will be tested at the shops where it is to be used. If it fails to meet these specifications, it will be rejected and returned at the expense of the manufacturer.

R. S. A. SPECIFICATIONS FOR WROUGHT IRON BARS.

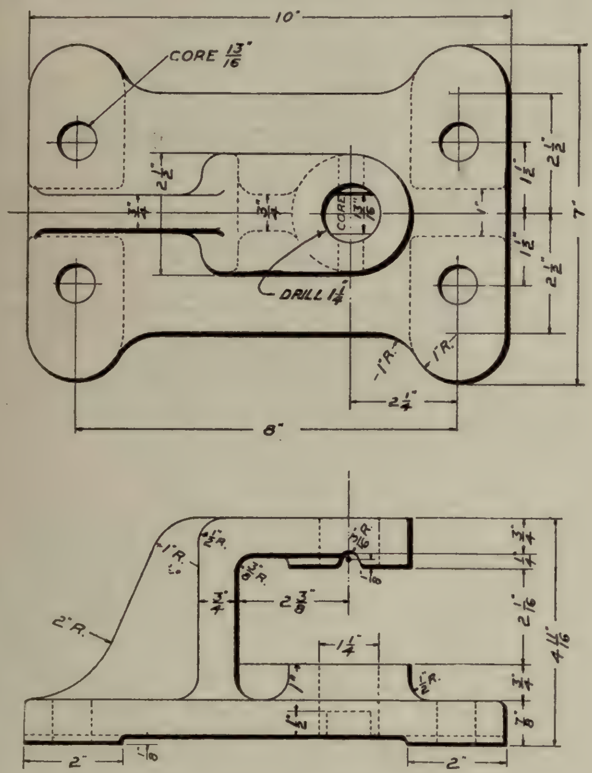
1. All sections must be true to size and shape ordered. Round iron must conform to the M. C. B. standard limit gauges.

2. Iron must be free from cracks, flaws, unwelded seams and mechanical defects of all kinds, and must be free from steel scrap.

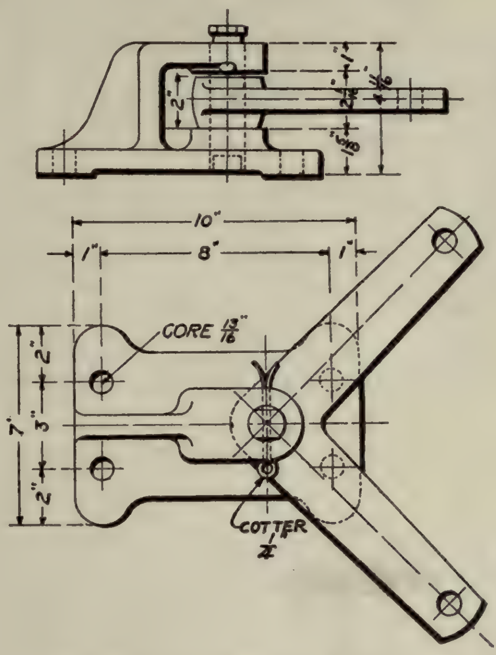
The fractures must not be more than 15 per cent. crystalline.

4. When subjected to bending test, either hot or cold, the iron must bend through an angle of 180 degrees around a diameter equal to twice the thickness of the bar without crack or fracture. In competent hands the iron must give perfect welds.

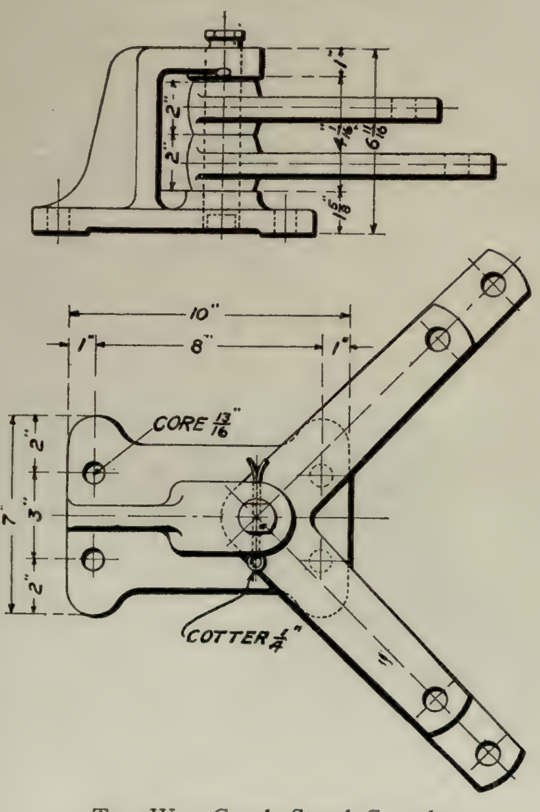
5. All iron showing defects in working, rendering it unfit for service, will be rejected and returned to manufacturer at his expense.



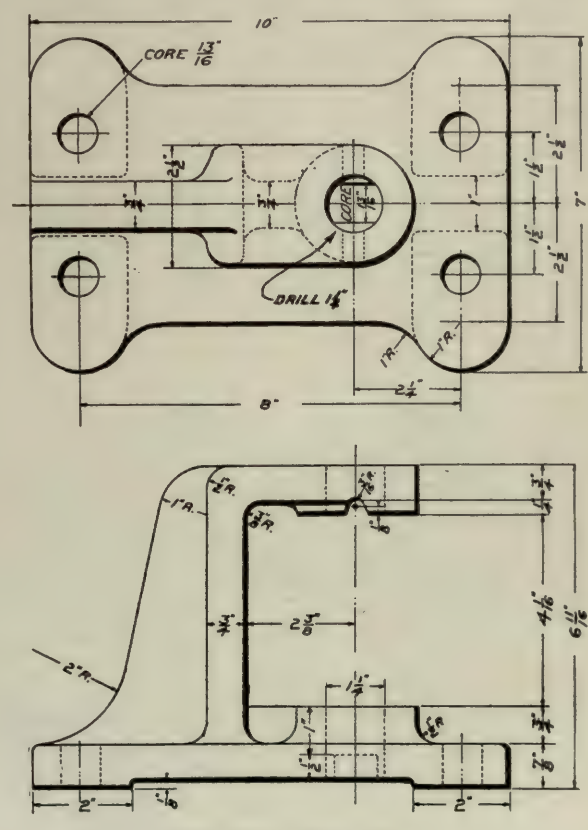
One-Way Crank Stand.



One-Way Crank Stand Complete.



Two-Way Crank Stand Complete.

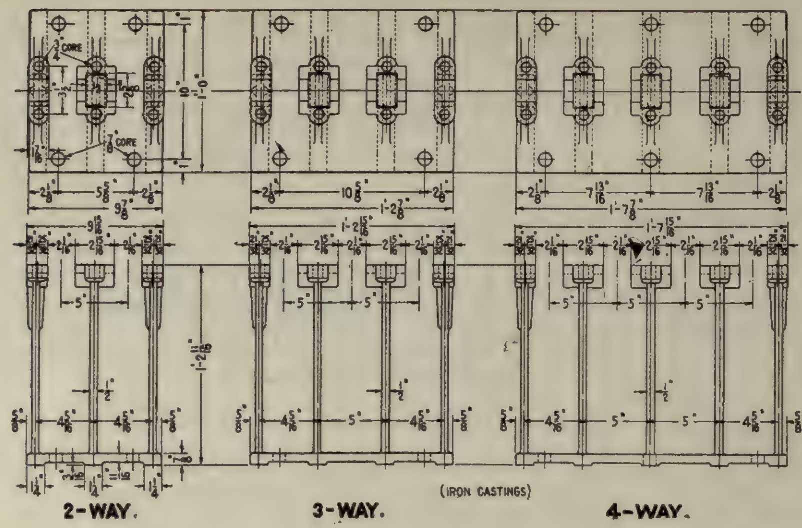


Two-Way Crank Stand.

Figs. 1146-1149. Railway Signal Association Standard Crank Stands.

3. Samples taken at random, one test specimen from 50 bars, approximately, must pass the following tensile test:
Tensile strength per square inch, not below 48,000 lbs.
Elongation in eight inches, not less than 20 per cent.

6. The iron shall be inspected at the shops where it is to be used and if it fails to meet the requirements of these specifications, it will be rejected and returned at the expense of the manufacturer.



Figs. 1150-1153. Details of Multiple Vertical Crank Stands. Railway Signal Association Standard.

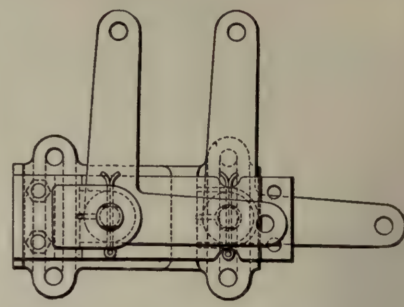


Fig. 1156.

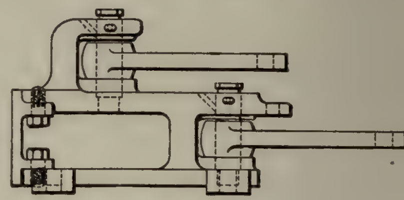
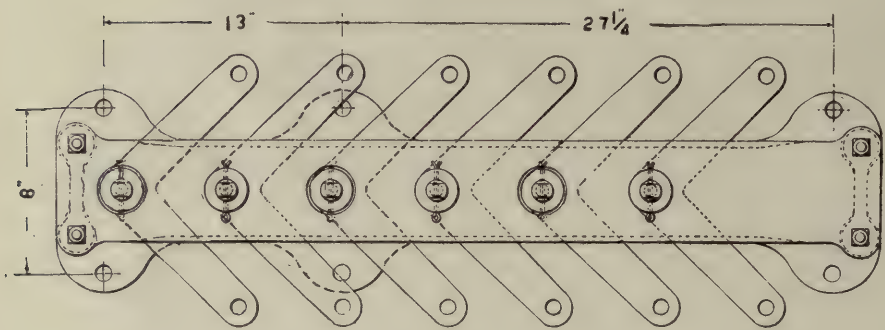


Fig. 1157.



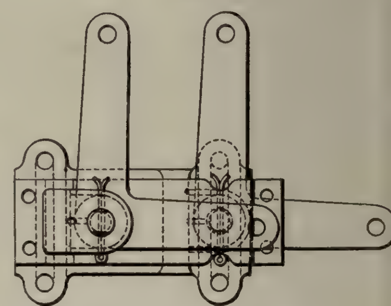
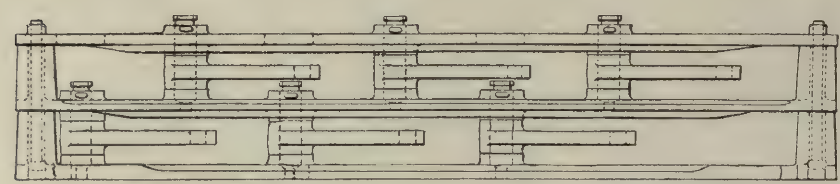


Fig. 1158.



Figs. 1154-1155. Box Crank, Cotters Above Frame.

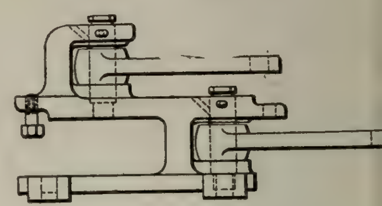


Fig. 1159.

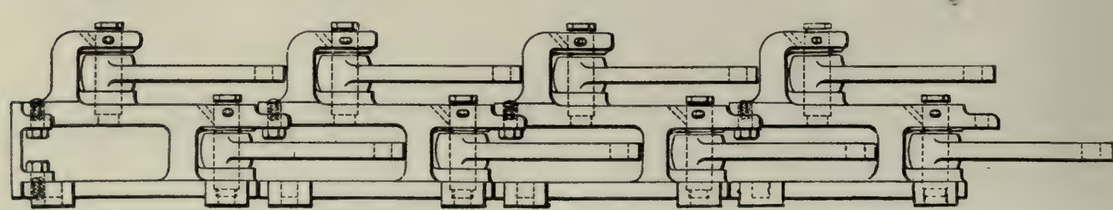
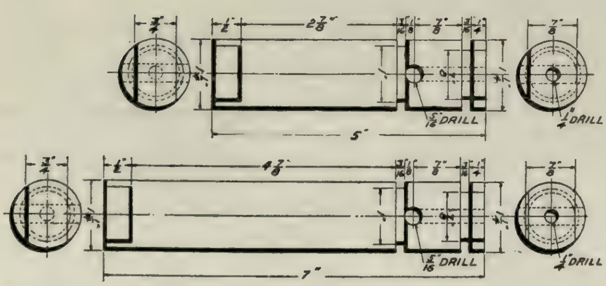


Fig. 1160.

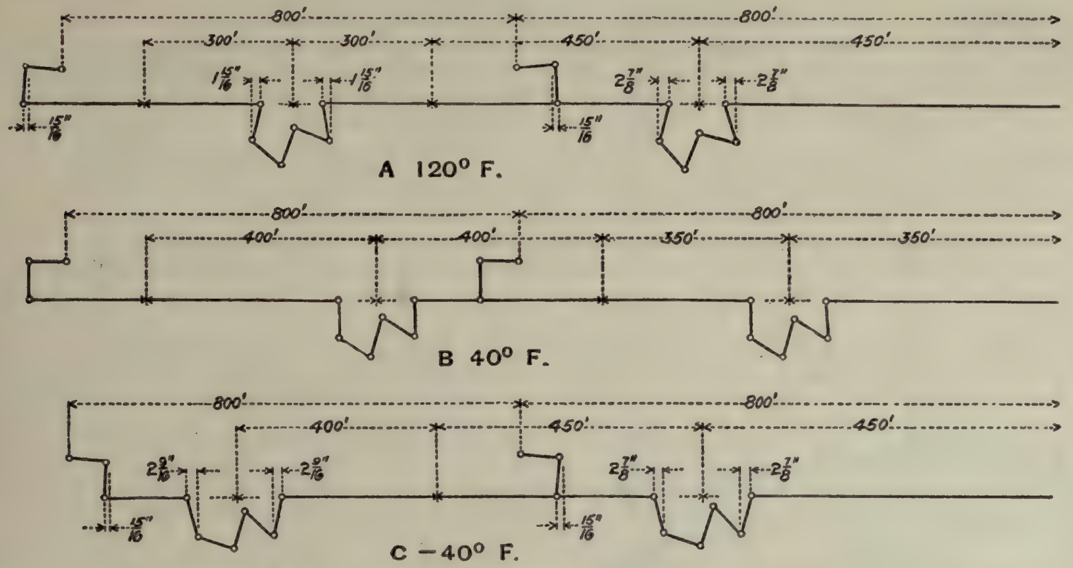
Figs. 1156-1160. Separate Pin Leadout Cranks.



Figs. 1161-1162. One and Two Way Crank Pins. R. S. A. Standard.

COMPENSATORS.

The connection between a lever and its function being equivalent to a solid iron rod, expansion and contraction will accompany change in temperature. Provision must be made to overcome the effects of such expansion and contraction, as otherwise on a warm day the pipe line would be too long and on a cold day too short. This would prevent levers and their functions from making full stroke in one direction or the other. Serious variations in length might take place between morning and noon. For this reason *compensators* are used. A compensator reverses the direction of travel in the pipe line so that expansion or contraction in different portions of the line counteract each other. Where there are no branch lines and only one compensator is used, it should be placed midway between the lever and its function. Should



Figs. 1163-1164. Diagrams Showing Effects of Temperature Changes in Pipe Lines. (See Table Below.)

there be branch lines, as when two functions are operated from one lever, one compensator should be placed midway between the end of the shorter branch and the lever; and a second compensator should be placed a distance from the end of the longer branch equal to half the difference in length of the two branches. Three or more branches can be treated in a similar manner. If two or more compensators are to be used and there are no branches, they should not be evenly spaced, but each should be in the middle of the section of the pipe line to be compensated. For instance, if two are used, one should be placed a distance from the lever equal to one-quarter the length of the line, and the second the same distance from the function. A compensator may consist of a straight crank (Figs. 1174-1175 and 1185-1204), or a "lazy-jack" (Figs. 1163-1164). The latter consists of two cranks, one at 60

Temp. Deg. Fahr.	Lengths of Pipe Line in Feet. 100	150	200	250	300	350	400	450	
120	5/8	15/16	1 1/4	1 5/8	1 15/16	2 1/4	2 9/16	2 7/8	Inches long.
110	9/16	13/16	1 1/8	1 3/8	1 11/16	1 15/16	2 1/4	2 1/2	
100	1/2	3/4	15/16	1 13/16	1 7/16	1 11/16	1 15/16	2 3/16	
90	3/8	5/8	13/16	1	1 3/16	1 3/8	1 5/8	1 13/16	
80	5/16	1/2	5/8	13/16	15/16	1 1/8	1 1/4	1 7/16	
70	1/4	3/8	1/2	5/8	3/4	13/16	15/16	1 1/16	
60	3/16	1/4	5/16	3/8	1/2	9/16	5/8	3/4	
50	1/16	1/8	3/16	3/16	1/4	1/4	5/16	3/8	
40				Mean					
30	1/16	1/8	3/16	3/16	1/4	1/4	5/16	3/8	Inches short.
20	3/16	1/4	5/16	3/8	1/2	9/16	5/8	3/4	
10	1/4	3/8	1/2	5/8	3/4	13/16	15/16	1 1/16	
0	5/16	1/2	5/8	13/16	15/16	1 1/8	1 1/4	1 7/16	
—10	3/8	5/8	13/16	1	1 3/16	1 3/8	1 5/8	1 13/16	
—20	1/2	3/4	15/16	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16	
—30	9/16	13/16	1 1/8	1 3/8	1 11/16	1 15/16	2 1/4	2 1/4	
—40	5/8	15/16	1 1/4	1 5/8	1 15/16	2 1/4	2 9/16	2 1/8	

Note.—The figures in this table are approximately correct. The basis is .008" on every 100' for 1° F. variation in temperature.

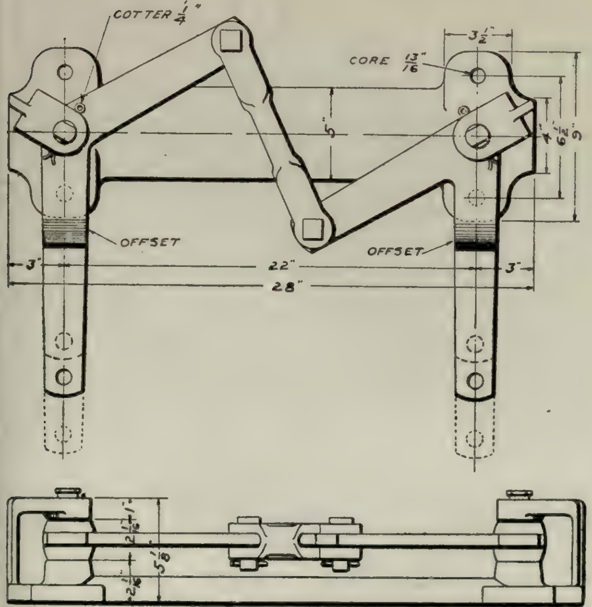


Fig. 1165. Pipe Compensator. R. S. A. Standard.

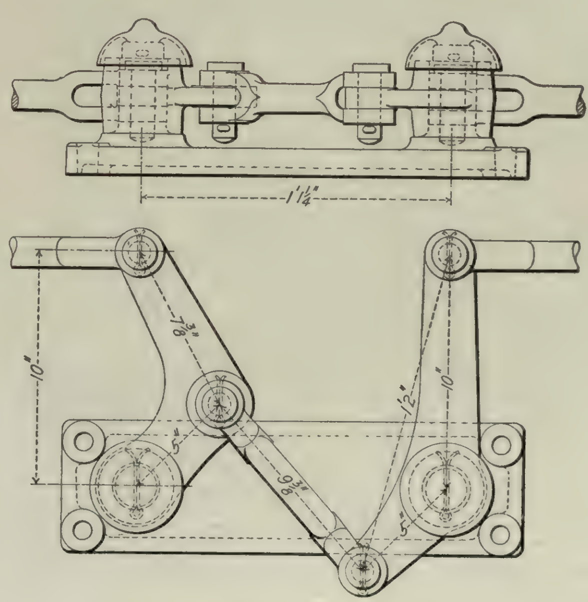


Fig. 1166. Parallel Compensator. Great Western Railway of England.

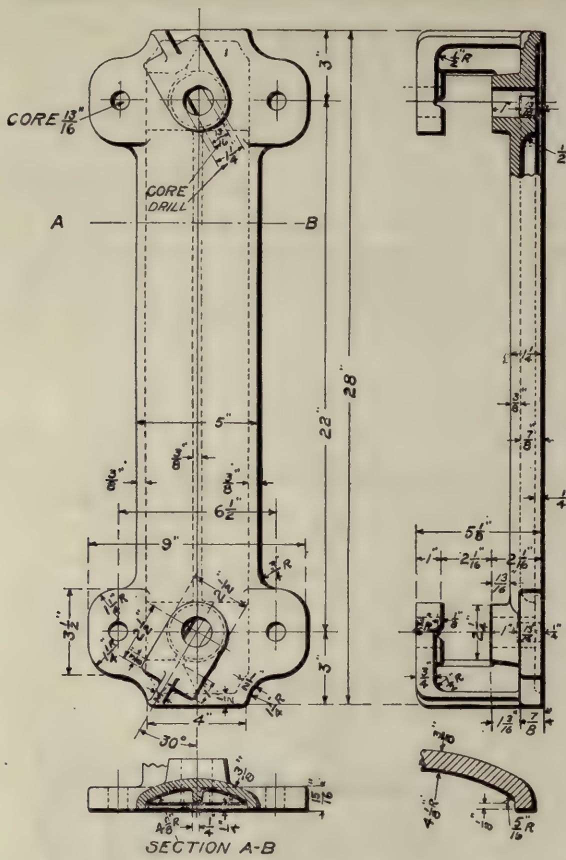
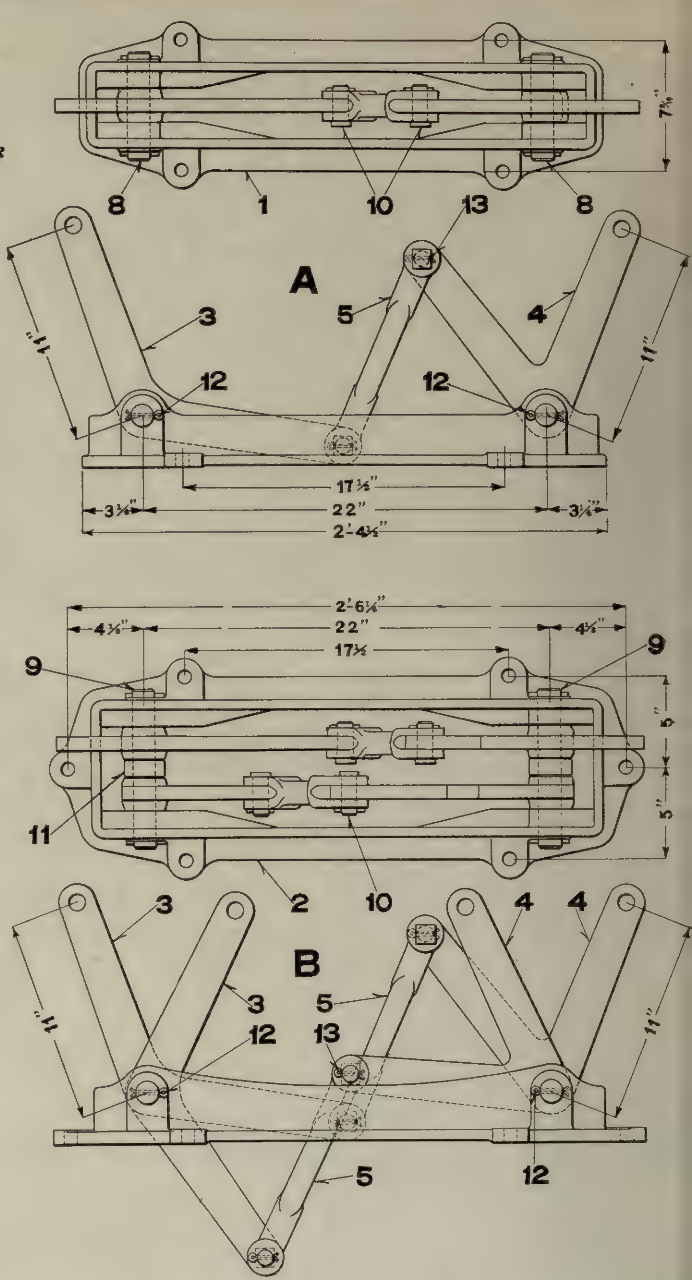


Fig. 1167. One Way Compensator Base. R. S. A. Standard.

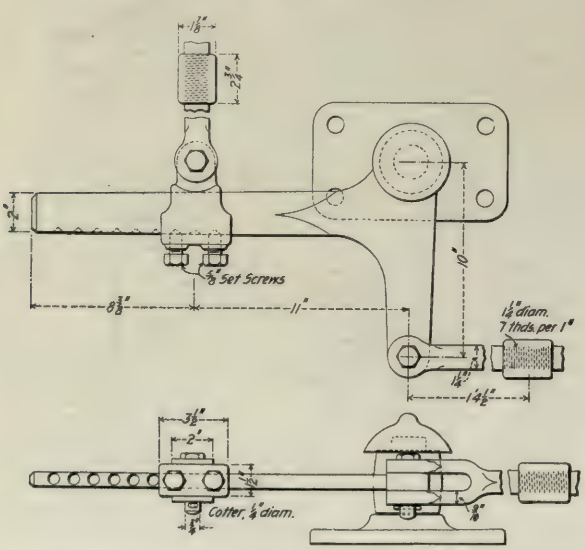
Names of Parts, Vertical Lazy Jack Compensators; Figs. 1168-1171.

A *One-Way Vertical Lazy Jack Compensator*
B *Two-Way Vertical Lazy Jack Compensator*
1 *One-Way Stand*
2 *Two-Way Stand*
3 11" x 11" *Obtuse Angle Crank*
4 11" x 11" *Acute Angle Crank*
5 *Connecting Link*
8 *Center Pin for* **A**
9 *Center Pin for* **B**
10 *Jaw Pin*
11 *Spacing Washer*
12 *Cotter*
13 *Cotter*

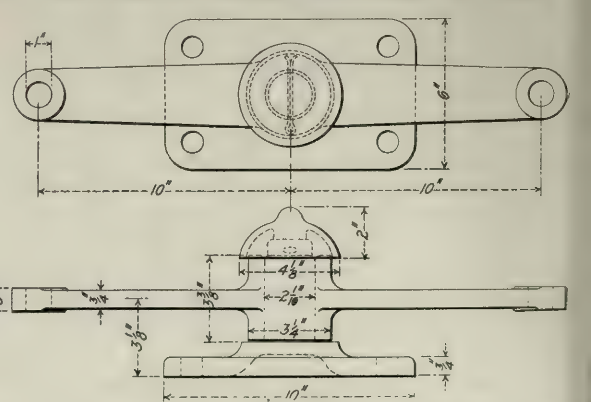


Figs. 1168-1171. Vertical Lazy Jack Pipe Compensator.

deg., the other at 120 deg., mounted on a base and connected by a short link. By using this device the pipe can be continued in a straight line while the direction of its motion is reversed. Sometimes it is possible to compensate a pipe line by using one or more cranks, so arranged as to reverse the motion.



Figs. 1172-1173. Adjustable Crank. Great Western of England.



Figs. 1174-1175. Straight Arm Compensator. Great Western of England.

It is customary in connecting up pipe lines to set all apparatus "on center" so that the throw may be equal in each direction, but to provide proper compensation and take care of all temperature effects the table shown in connection with

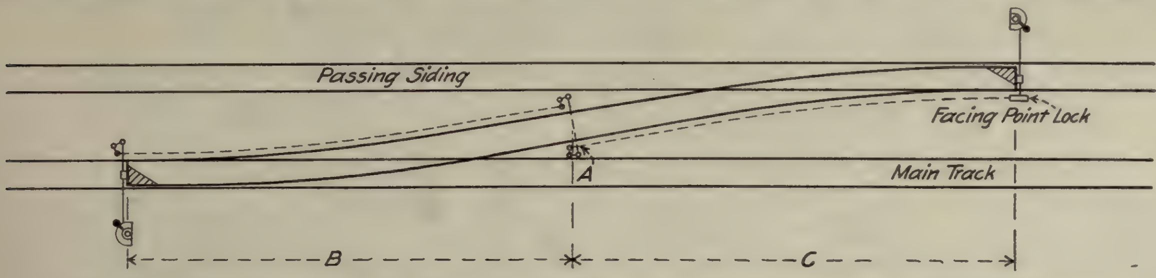
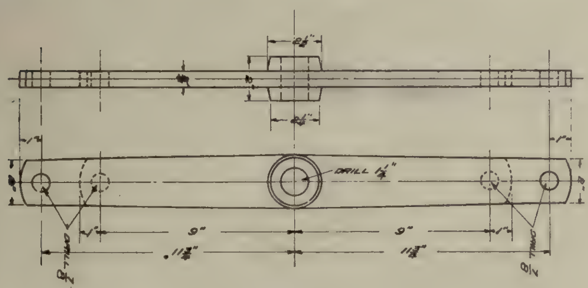


Fig. 1176. Self-Compensating Pipe Run for Pipe Connected Crossover. Michigan Central.

Figs. 1163-1164 should be used, cutting the pipe long when the temperature is above the mean and short when below. In this way the throw will be equalized. Otherwise the throw of the cranks will be further on one side of center in warm weather than on the other side in cold weather. Figs. 1162-1164 show diagrammatically the effects of temperature on pipe lines. The coefficient of expansion of iron, .008 in. per 100 ft. one deg. F., is used as the basis of the table and diagram. If the mean temperature of the locality in which



Figs. 1177-1178. Straight Arm Crank. R. S. A. Standard.

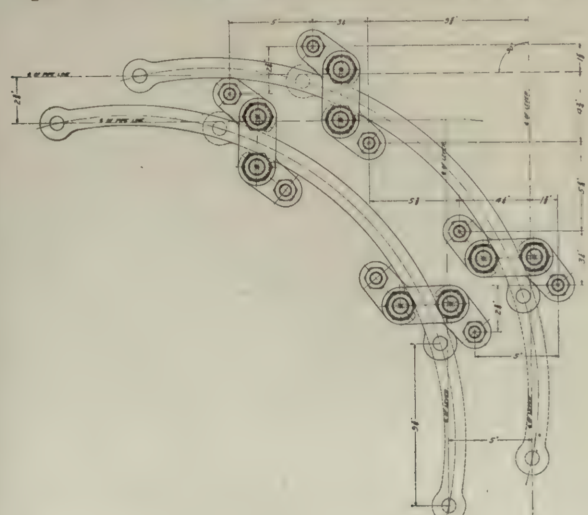
the plant is situated is other than 40 deg., it should be ascertained and the table corrected accordingly.

Cranks and compensators are mounted on stands or foundations made of iron legs with wooden tops and bottoms or of concrete (Figs. 1261-1267 and 1242-1245), similar to those used for pipe carriers.

DEFLECTING BARS.

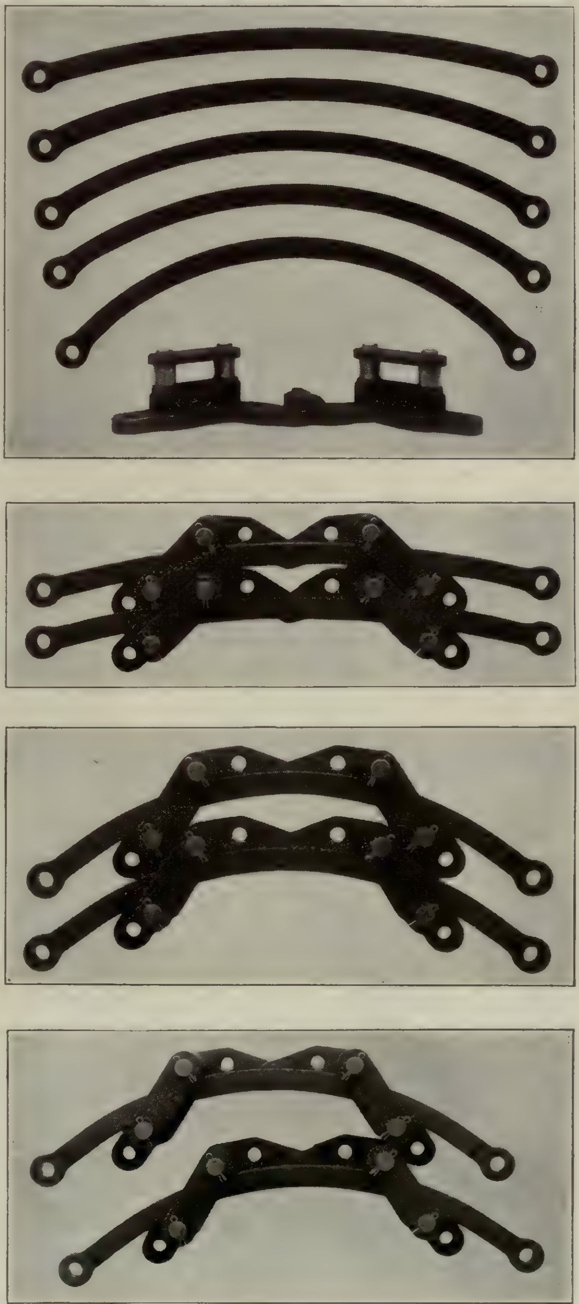
Figs. 1179-1180 illustrate the Federal horizontal deflecting bar for making a right angle turn.

Figs. 1181-1184 illustrate the G. R. S. adjustable deflecting bar stand with deflecting bars varying from 22½ to 90 deg. The stands can be installed wherever it is practicable to use a curved bar for making an angle or turn in the pipe lines, without changing the center line of the pipe run; and the stand can be used with any of the cranks which are shown in Fig. 1181.



Figs. 1179-1180. Federal Horizontal Deflecting Bar.

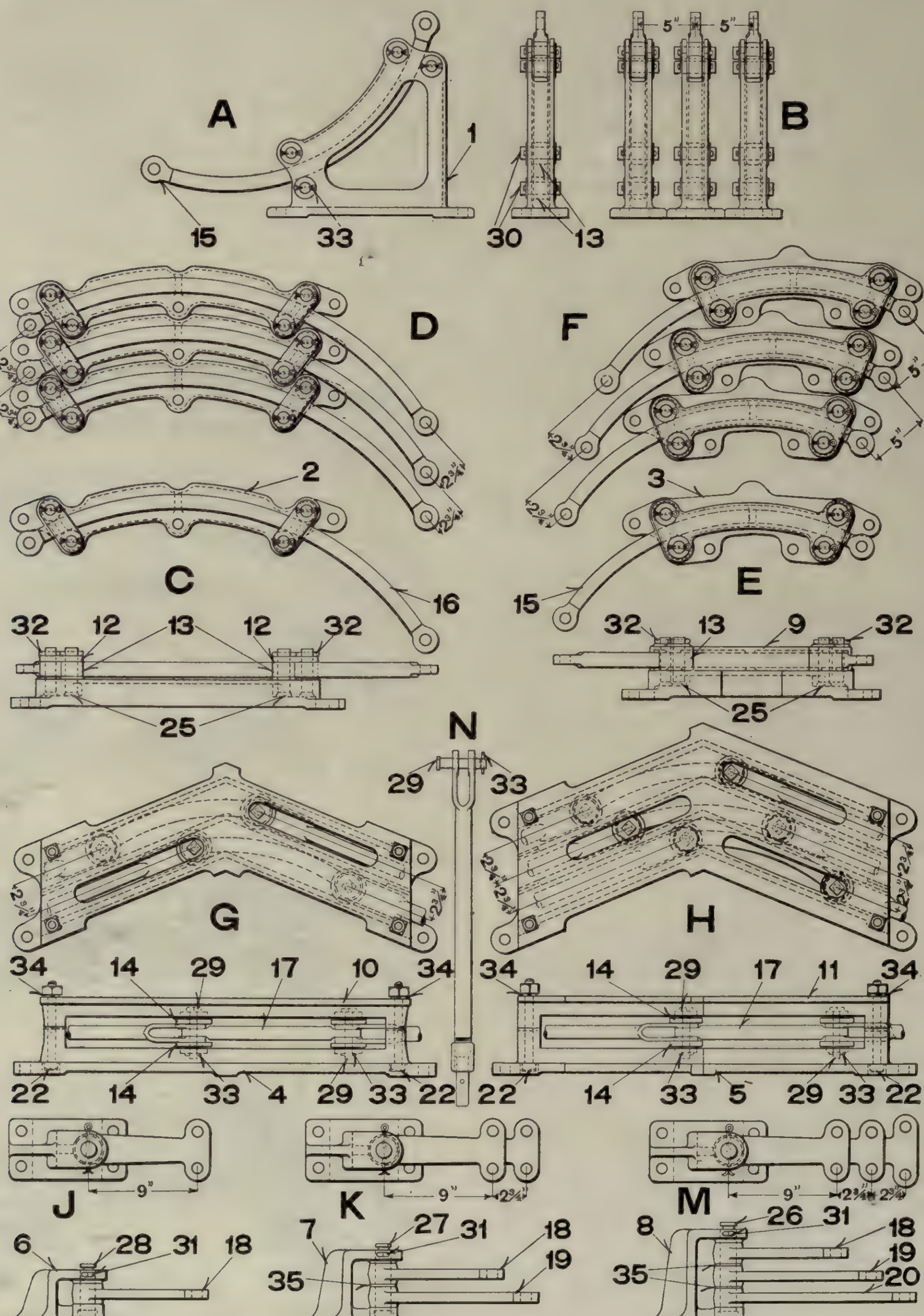
The stand, which with one bar forms a complete unit, can be assembled in groups of as many "ways" as may be required, always maintaining the proper centers of the pipe line with whatever degree bar is used. The stands are designed with parallel bearing surfaces to facilitate the spacing of adjacent stands. Fig. 1182 illustrates the assembly of two bars set parallel to each other, making a turn of 22½ deg. in the pipe line. Fig. 1183 shows a similar assembly, but with bars for making a 90-deg. angle. Fig. 1184 illustrates the assembly



Figs. 1181-1184. Deflecting Bars, General Railway Signal Company.

of two bars spaced for leading from lever to pipe line (i. e., from five in. to 2¾ in. centers), as required at all interlocking tower leadouts.

In cases of necessity, if the proper degree bar is not obtainable a 90-deg. bar, for instance, may be flattened to the curvature of a 22½ deg. bar.



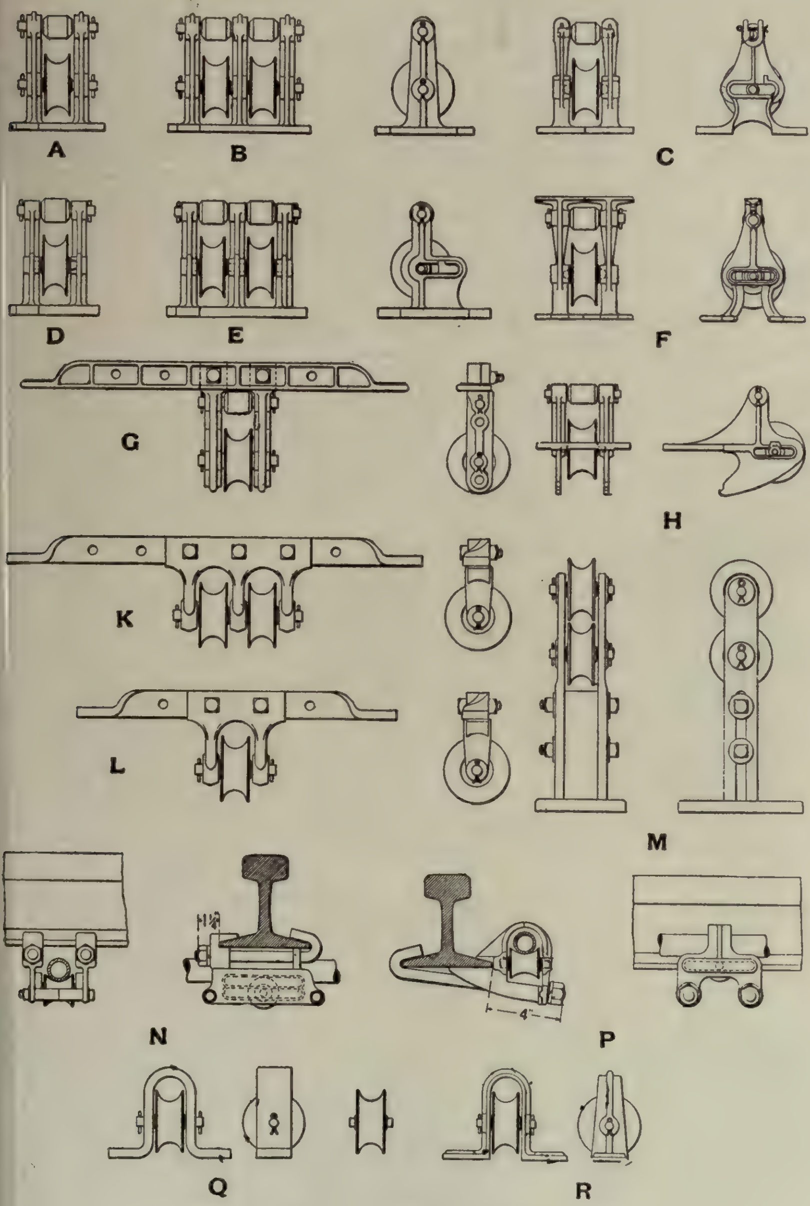
Figs. 1185-1204. Deflecting Bars and Radial Arms.

Names of Parts of Deflecting Bars and Radial Arms; Figs. 1185-1204.

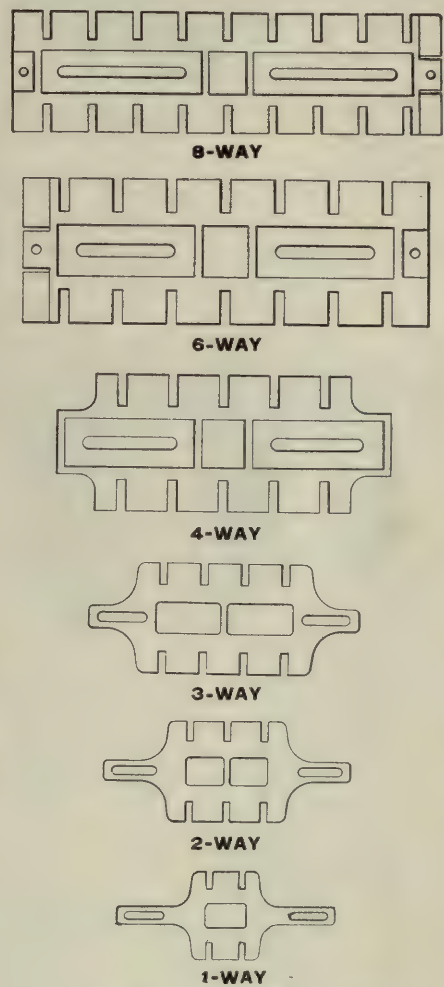
A *Vertical Deflecting Bar*
B *Group of Three Vertical Deflecting Bars*
C *Horizontal Deflecting Bar*
D *Group of Three Horizontal Deflecting Bars*
E *Short Horizontal Deflecting Bar*
F *Group of Three Short Horizontal Deflecting Bars*
G *Deflecting Stand, Two Way*
H *Deflecting Stand, Three Way*
J *Radial Arm and Stand, One Way*
K *Radial Arm and Stand, Two Way*
M *Radial Arm and Stand, Three Way*
N *Wrought Jaw for* **G** *and* **H**
1 *Vertical Deflecting Bar Frame*
2 *Horizontal Deflecting Bar Frame*
3 *Short Horizontal Deflecting Bar Frame*
4 *Deflecting Stand Base, Two Way*
5 *Deflecting Stand Base, Three Way*
6 *Radial Arm Stand, One Way*
7 *Radial Arm Stand, Two Way*
8 *Radial Arm Stand, Three Way*
9 *Cover for Short Deflecting Bar Frame*
10 *Cover for* **G**
11 *Cover for* **H**
12 *Cap for* **2**
13 *Roller*
14 *Washer*
15 *Short Radial Rod*
16 *Long Radial Rod*
17 *Link*
18 *9" Radial Arm*
19 *11¾" Radial Arm*
20 *14½" Radial Arm*
22 *Bolt*
25 *Pin*
26 *Center Pin for* **M**
27 *Center Pin for* **K**
28 *Center Pin for* **J**
29 *Jaw Pin for* **N**
30 *Roller Pin*
31 *Cotter*
32 *Cotter*
33 *Cotter*
34 *Spring Washer*
35 *Spacing Washer*

PIPE AND WIRE CARRIERS AND FOUNDATIONS.

Pipe is guided and supported by pipe carriers (Figs. 1205-1233 and 1254-1259). They consist of an iron frame carrying wheels or rollers between which the pipe moves. Those in which the hub of the wheel travels in a slot are known as anti-friction pipe carriers (Figs. 1254-1256 and C, E, F, H, N and P, Figs. 1205-1233); sometimes the roller also is made anti-friction. These pipe carriers are fastened by lag screws to long ties or to foundations. They may be made in units to be mounted side by side or in groups of any required number. The foundations may consist of concrete to which a block of wood is attached (Figs. 1242-1247), or of iron legs bolted to two wooden blocks. They are set in the ground a sufficient distance from the nearest rail to provide clearance for the carriers (Fig. 1241). Carriers are usually spaced not more than seven ft. apart as the pipe is under strain both in tension and compression. Where pipe lines cross the track, transverse or hanging pipe carriers are used (G, K, and L. Figs. 1215-1219, and Figs. 1242-1254), these being secured to the ties with lag screws.



Figs. 1205-1233. Pipe Carriers.



Figs. 1234-1239. Universal Pipe Line Carrier Base. W. K. Kenly Company.

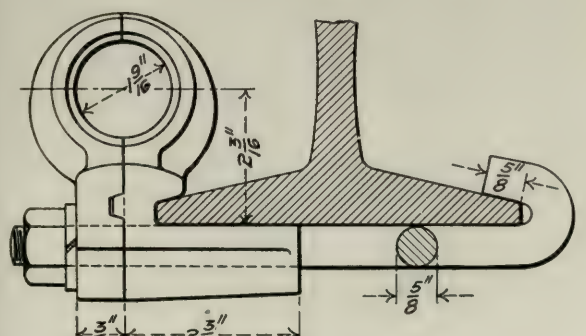


Fig. 1240. Rail Pipe Support. Michigan Central.

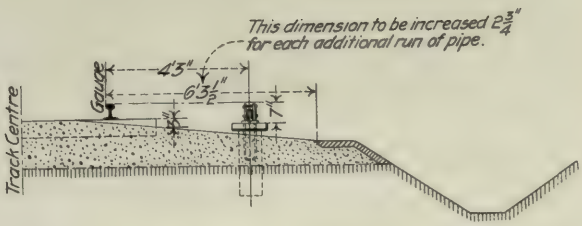
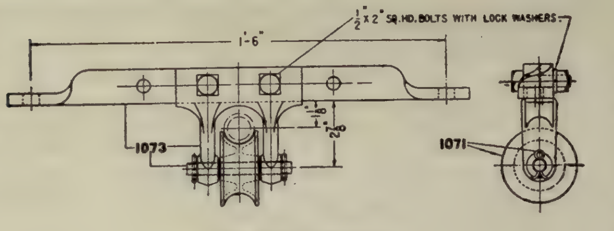
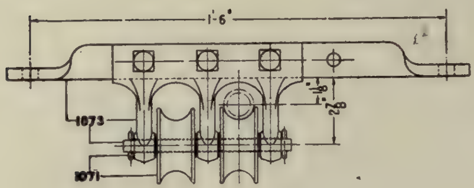


Fig. 1241. Standard Clearance for Pipe Lines. New York Central & Hudson River.



ONE-WAY, COMPLETE.

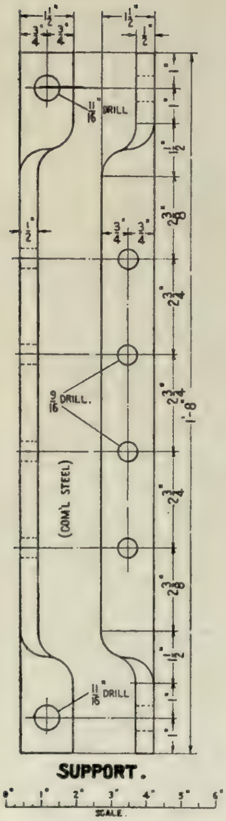


TWO-WAY, COMPLETE.

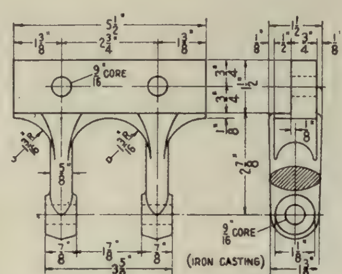
Figs. 1242-1243. R. S. A. Transverse Pipe Carriers.

Names of Parts; Figs. 1205-1233.

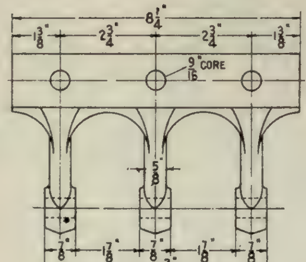
- **A** *One Way Plain Pipe Carrier*
- **B** *Two Way Plain Pipe Carrier*
- **C** *One Way "Universal" Pipe Carrier*
- **D** *One Way Anti-Friction Pipe Carrier*
- **E** *Two Way Anti-Friction Pipe Carrier*
- **F** *One Way "Universal" Pipe Carrier*
- **G** *Transverse Pipe Carrier, One Way*
- **H** *Special One Way Anti-Friction Pipe Carrier for Fastening to Ties*
- **K** *Two Way Transverse Pipe Carrier*
- **L** *One Way Transverse Pipe Carrier*
- **M** *Adjustable Pipe Guide*



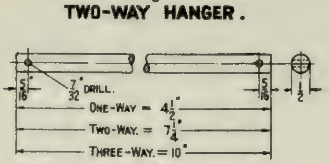
SUPPORT.



ONE-WAY HANGER.



TWO-WAY HANGER.



PINS. (C.R.STEEL.)

FOR DETAILS OF SHEAVE AND COTTER PIN SEE NO.1071.
FOR ASSEMBLY DRAWING SEE NO.1072.

Figs. 1251-1254. Details of R. S. A. Transverse Pipe Carriers.

UNIVERSAL PIPE LINE CARRIER BASE.

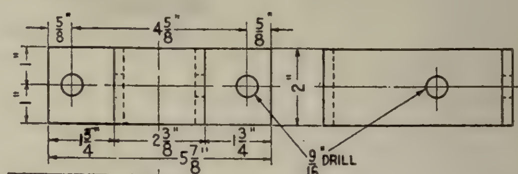
This device is made of malleable iron and was designed as an improvement over the old wooden base which has been in use for so many years. The use of this base effects a considerable saving in labor, both during and after the time of installation of a plant, on account of the fact that no renewal is necessary every six or eight years, as is the case when wooden bases are used.

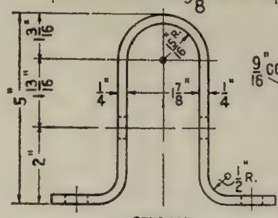
Mechanically, the malleable base does away with lag screws and affords an easier lever manipulation, on account of the increased rigidity of the malleable construction over wood. A lateral adjustment can be made after installation of the base on the concrete block, and a second adjustment of the pipe carrier if necessary. The difference in price between the malleable and wooden tops is slight.

The base is designed to mount the universal pipe carrier now in common use. Two patterns are furnished, for the carrier bored for ¾ inch or ½ inch. Bases are furnished in six sizes, viz.: One, two, three, four, six and eight way; with six and eight way bases lap-jointed to provide for large plants. The various forms of base are shown in Figs. 1234-1239, the six and eight way bases having lap joints which prevent lateral or vertical displacement of the bases on a wide pipe run.

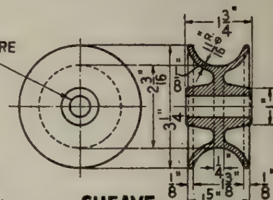
The Universal Pipe Line Carrier Base is made by the W. K. Kenly Co.

- **N** *One Way Rail Clip Transverse Pipe Carrier*
- **P** *Rail Clip Pipe Carrier*
- **Q** *Strap Pipe Carrier*
- **R** *Strap Pipe Carrier*

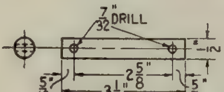




STAND. (COM'L STEEL)

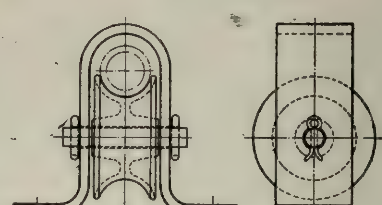


SHEAVE. (IRON CASTING)



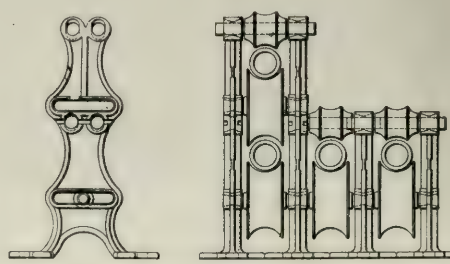
PIN. (C.R.STEEL)

COTTER PIN.

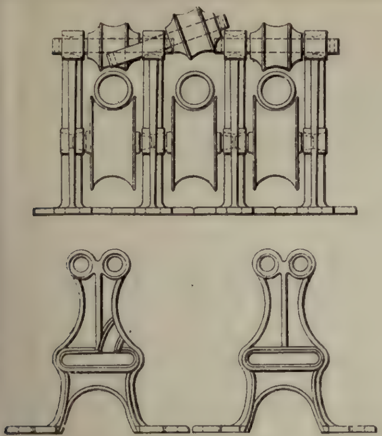


ASSEMBLY.

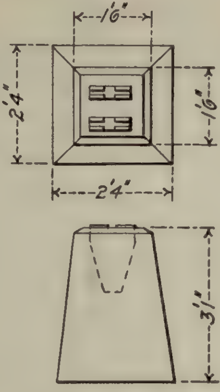
Figs. 1244-1250. Details of R. S. A. Strap Pipe Carrier.



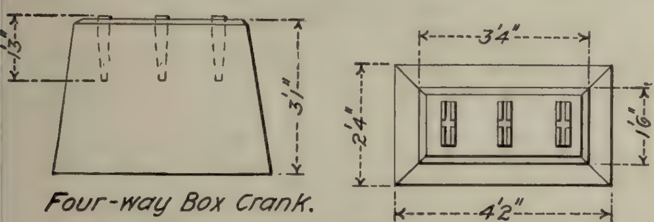
Figs. 1255-1256. Double and Single Deck Anti-Friction Pipe Carriers. T. George Stiles Company.



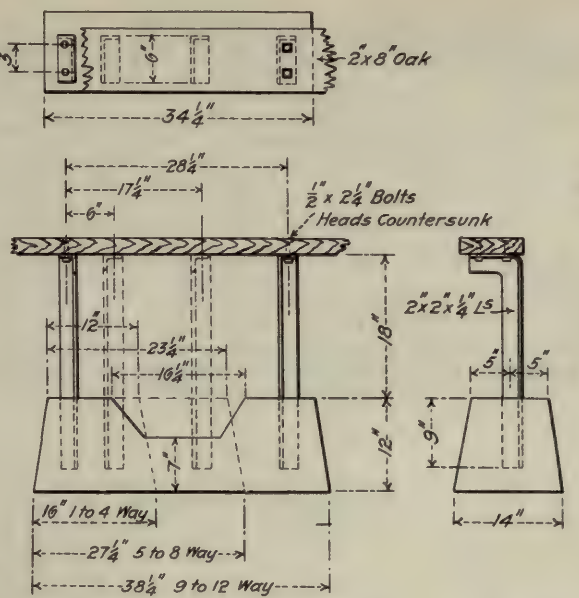
Figs. 1257-1258. "Universal" Anti-Friction Pipe Carriers. T. George Stiles Company.



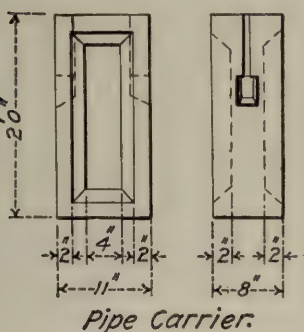
Figs. 1259-1260



Figs. 1261-1262.



Figs. 1265-1266. Standard Pipe Carrier Foundation, with Concrete Base. New York.



Figs. 1263-1264.

Figs. 1263-1264. Concrete Foundations. Michigan Central.

Figs. 1267. Pipe and Wire Carriers and Concrete Foundations. The Buffalo Railway Supply Company.

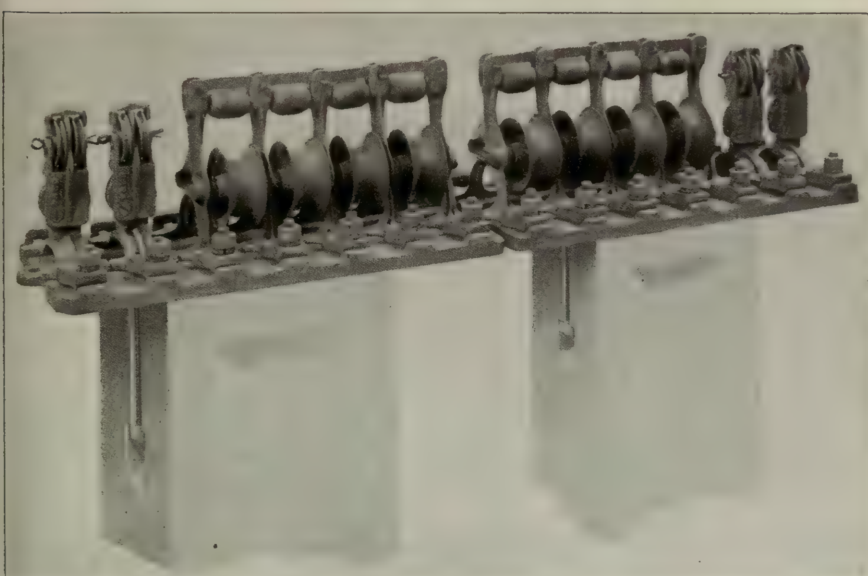


Fig. 1268. Iron Base for Pipe and Wire Carriers. Union Switch and Signal Company.

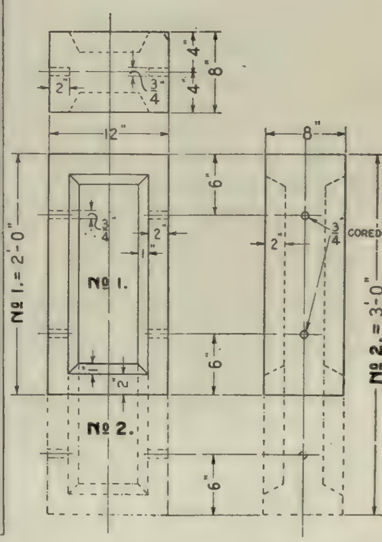
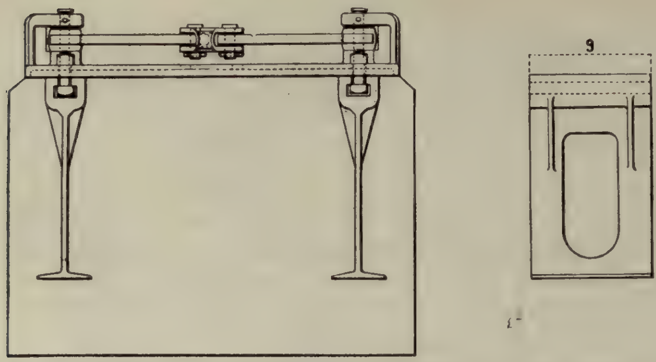
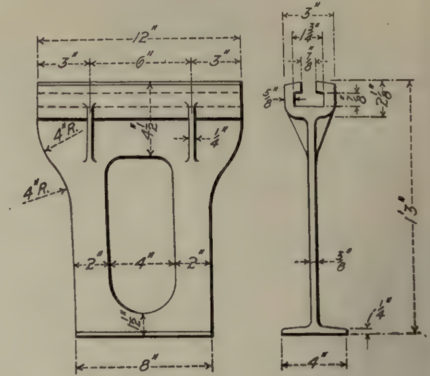


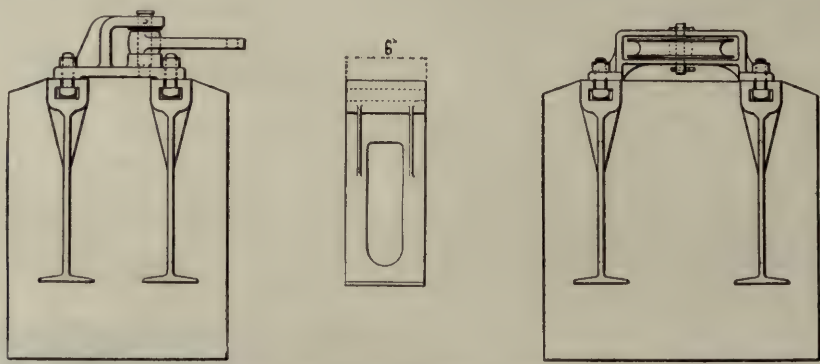
Fig. 1269. R. S. A. Standard Pipe Carrier Concrete Foundation.



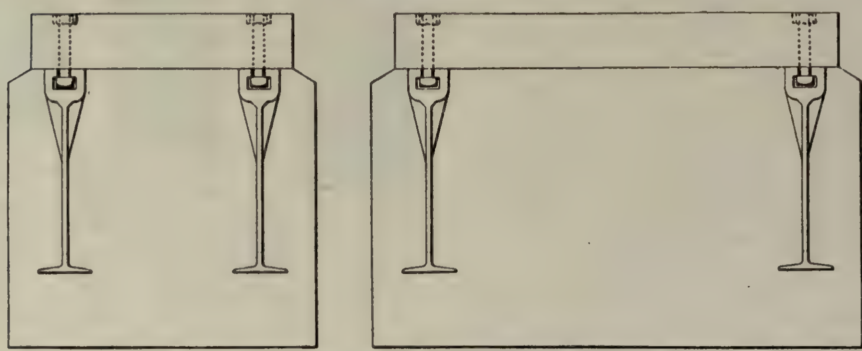
Figs. 1270-1271. Compensator Foundation; Iron Piers Set in Concrete.



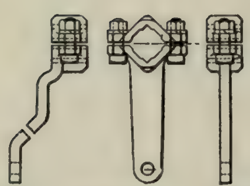
Figs. 1272-1273. Cast-Iron Pier for Concrete Foundation.



Figs. 1274-1276. Crank and Chain Wheel Foundations; Iron Piers Set in Concrete.



Figs. 1277-1278. Pipe Carrier Foundations; Wooden Tops, Bolted to Iron Piers, Set in Concrete.



Figs. 1279-1281. Arms for Square Rocker Shafts.

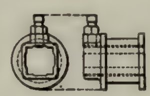
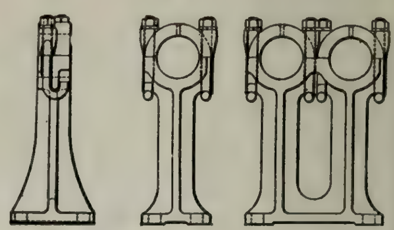
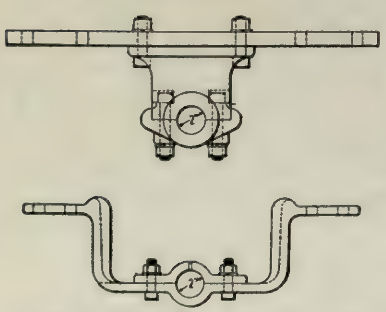
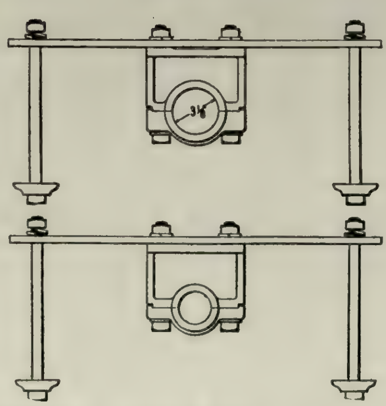


Fig. 1282. Journal for Square Rocker Shafts.

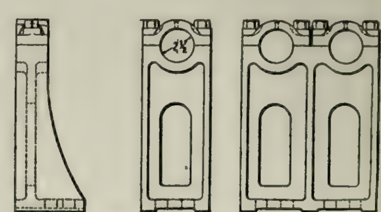


Figs. 1283-1285. Rocker Shaft Bearings for Square Rocker Shafts.





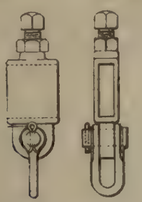
Figs. 1286-1289. Rocker Shaft Bearings for Use Between Ties.



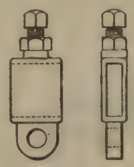
Figs. 1290-1292. Rocker Shaft Stands.

WIRE CONNECTIONS AND COMPENSATION.

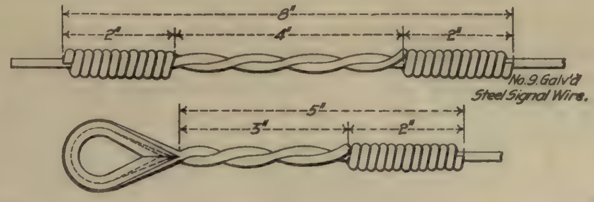
Wire is supported and guided by wire carriers (Figs. 1309-1333), mounted on stakes (Figs. 1336-1337 and 1334-1335), or on pipe carrier foundations. Where the direction of the line is changed, one-quarter in. proof chain is introduced into



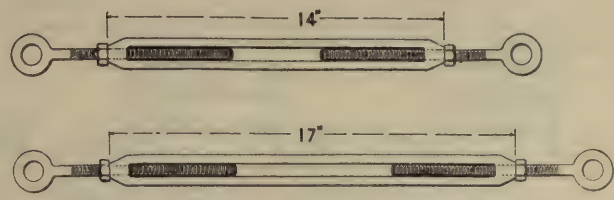
Adjustable Connector, with Shackle.



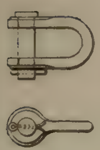
Adjustable Connector.



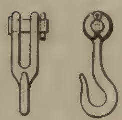
Figs. 1305-1306. Splice and Method of Attaching Wire Eye to Wire. New York Central.



Figs. 1307-1308. Wire Adjusting Screws.



Shackle.

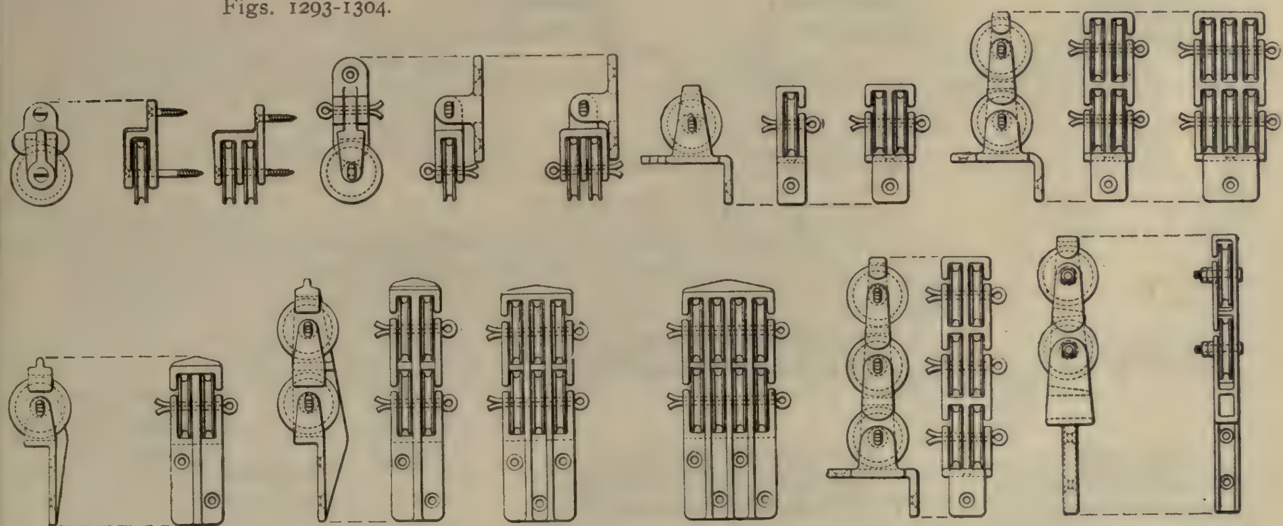


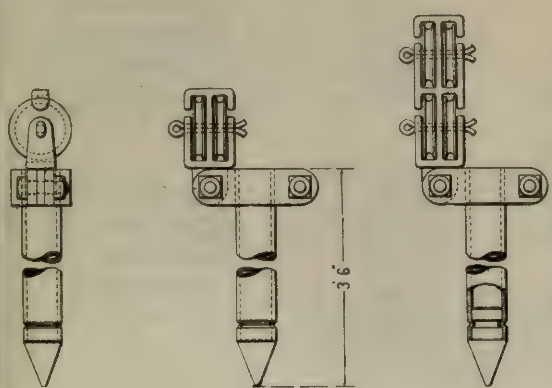
Hook Shackle.

Split Link.

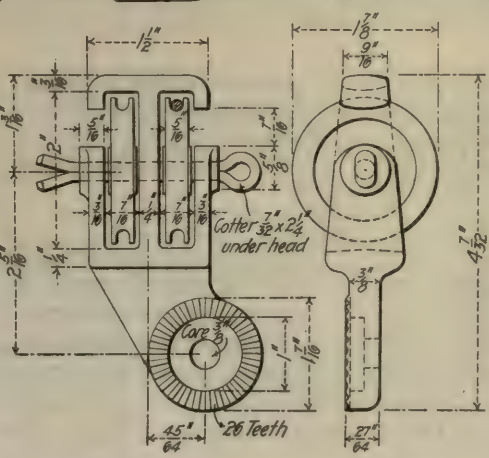
Double Shackle.

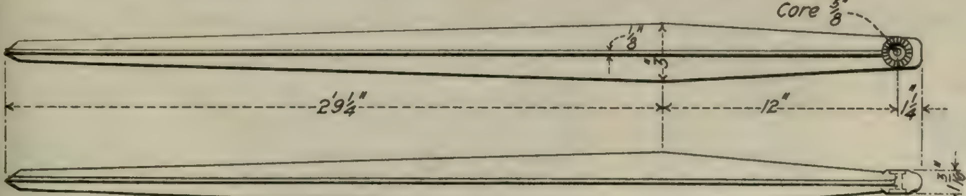
Figs. 1293-1304.



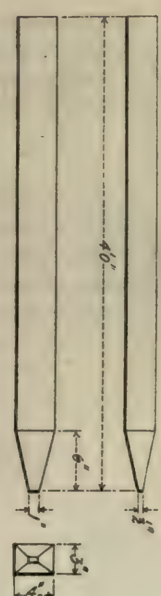


Figs. 1309-1333. Wire Carriers.

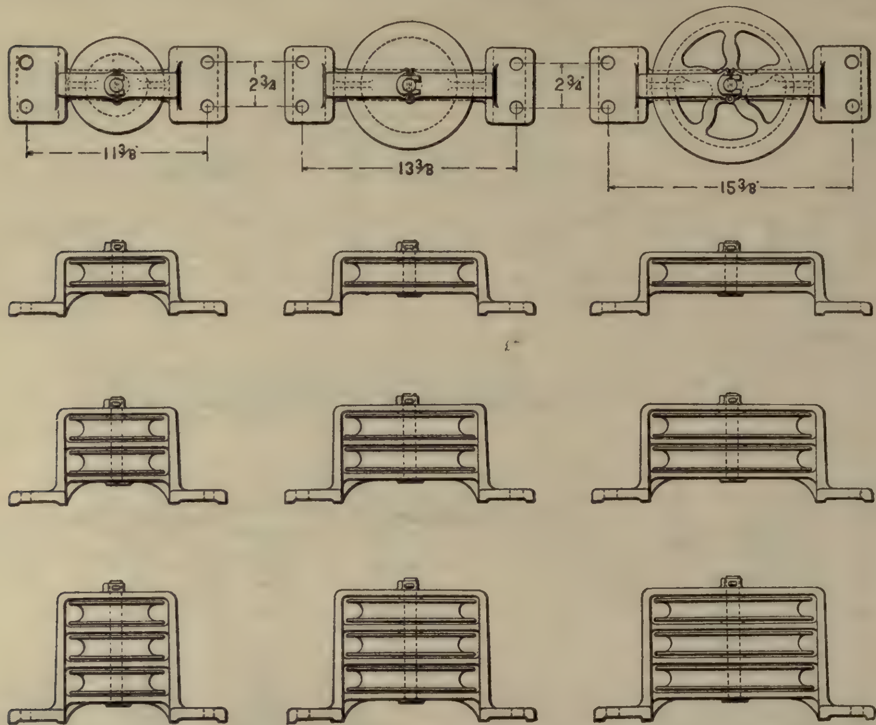




Figs. 1334-1335. Two-Way Adjustable Wire Carrier and Cast-Iron Stake. Buffalo Railway Supply Company.



Figs. 1336-1337. Wooden Stake for Wire Carriers.



Figs. 1338-1347. One, Two and Three Way Horizontal Chain Wheels.

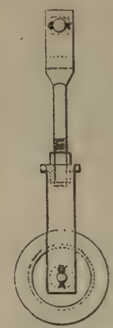


Fig. 1348.

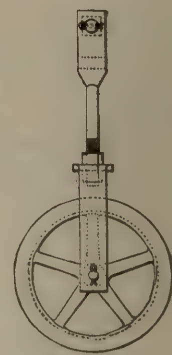
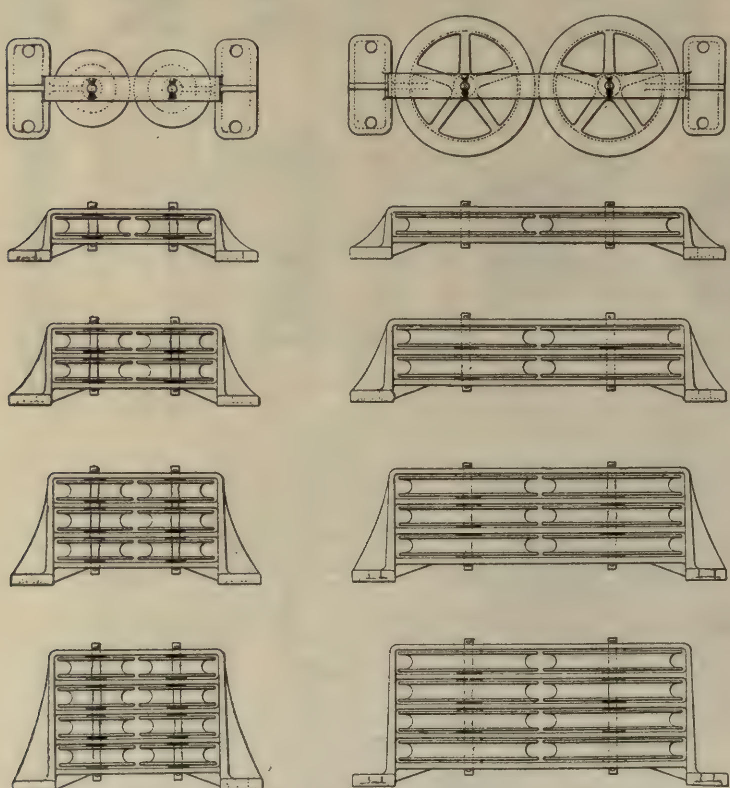
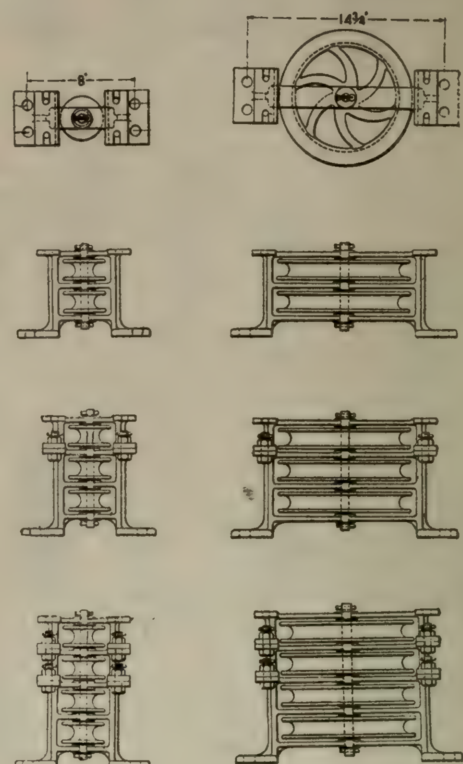


Fig. 1349.

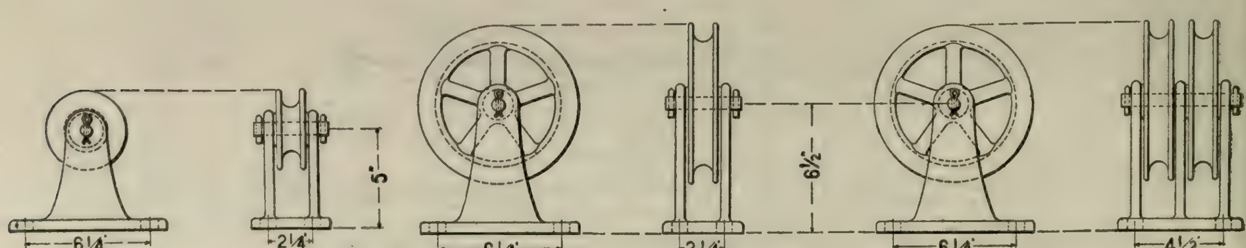
Figs. 1348-1349. Gain Stroke Chain Wheels.



Figs. 1350-1359. Types of Tandem Horizontal Chain Wheels.



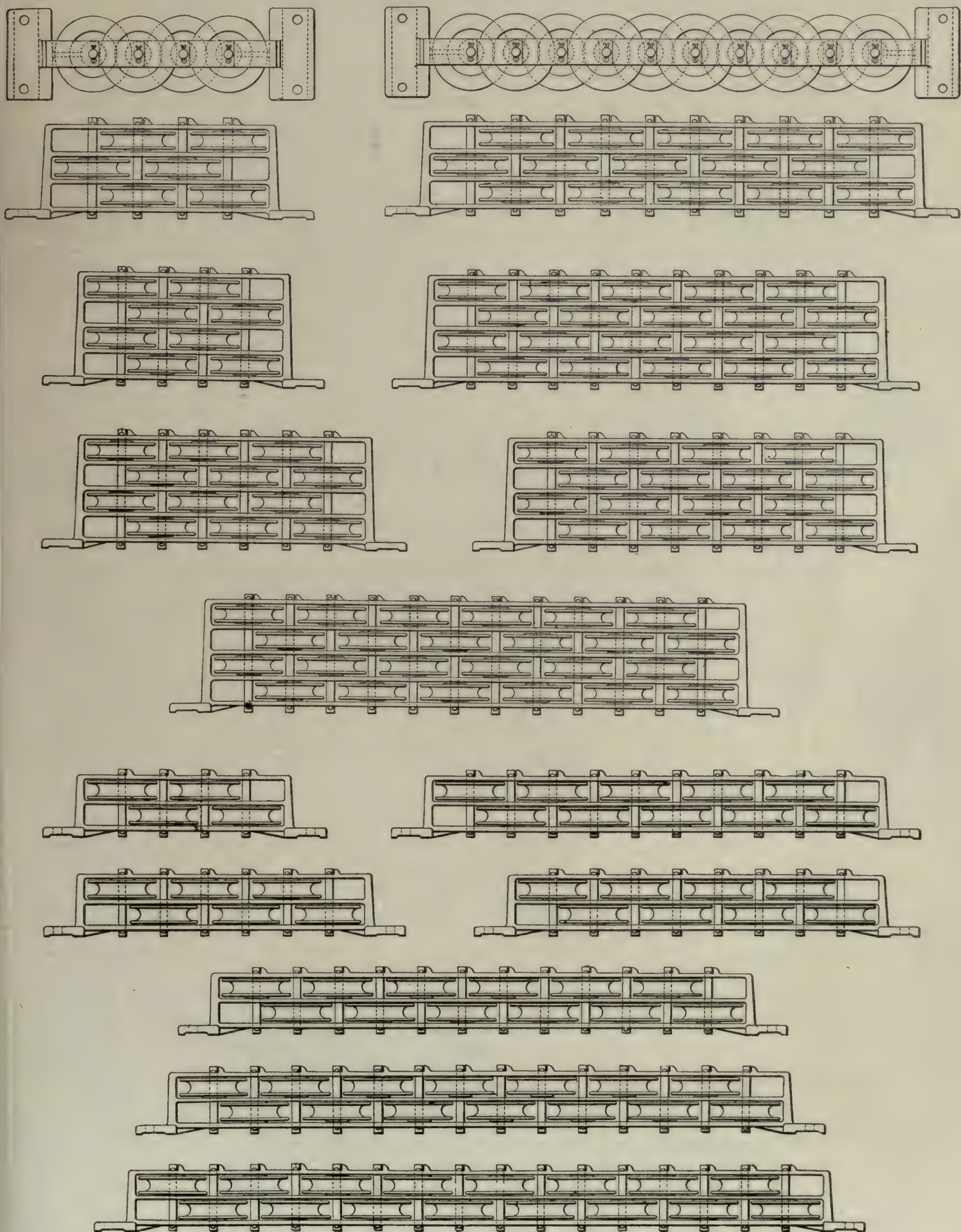
Figs. 1360-1367. Multiple Horizontal Chain Wheels.



Figs. 1368-1370. Types of Vertical Chain Wheels.

the line and led around chain wheels (Figs. 1339-1398). These are mounted on foundations like cranks. The chain is fastened to the wire by wire eyes and split links (Figs. 1293-1304).

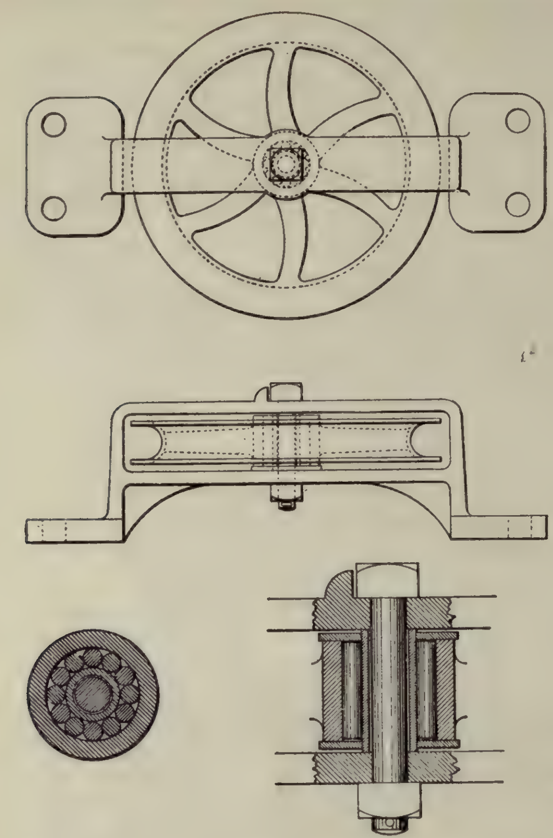
A wire compensator is shown in Figs. 1409-1410. Weight of connecting direct to balance lever 5, so that should the back wire break, the right-hand end of lever 8 will rise through link 7 until the lever assumes a nearly vertical position, when it will allow the pulling wire to slip off of



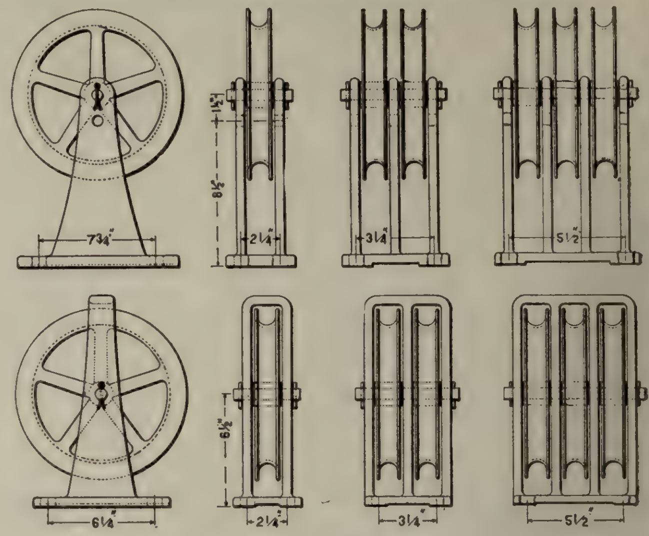
Figs. 1371-1386. Types of Box Wheels.

14 at end of lever 13, which carries chain wheels, takes up all slack in wires and keeps them taut. The weight of 14 is able to overcome that of the spectacle and counterweight 6 when signal is clear. Wires are hooked to the ends of disengaging lever 8 which rests in link 7. This is done instead the hook at its left-hand end, permitting lever 13 with its weight to drop harmlessly instead of pulling the signal clear.

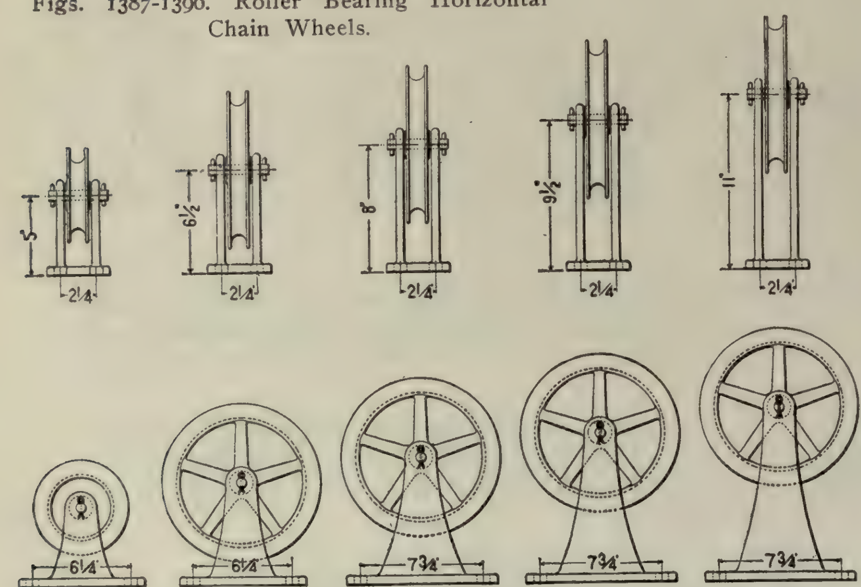
Figs. 1411-1412 illustrate a method by which a single wire signal may be adjusted by the signalman to changes in temperature.



Figs. 1387-1390. Roller Bearing Horizontal Chain Wheels.



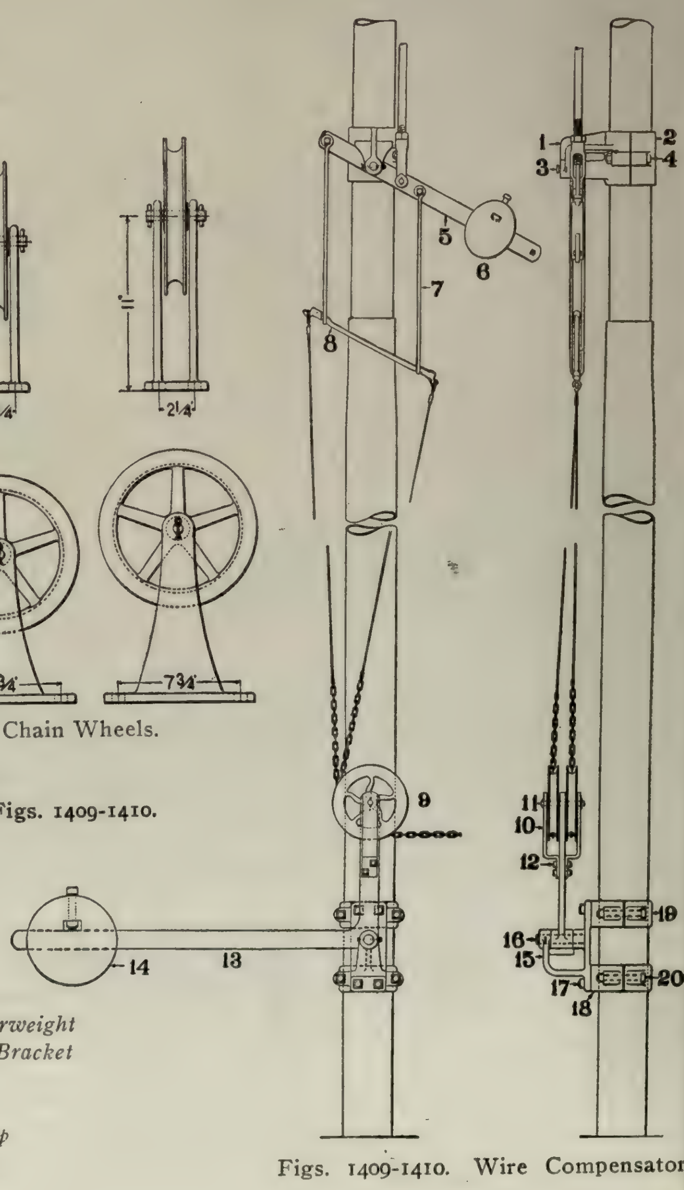
Figs. 1391-1398. Types of Vertical Chain Wheels.



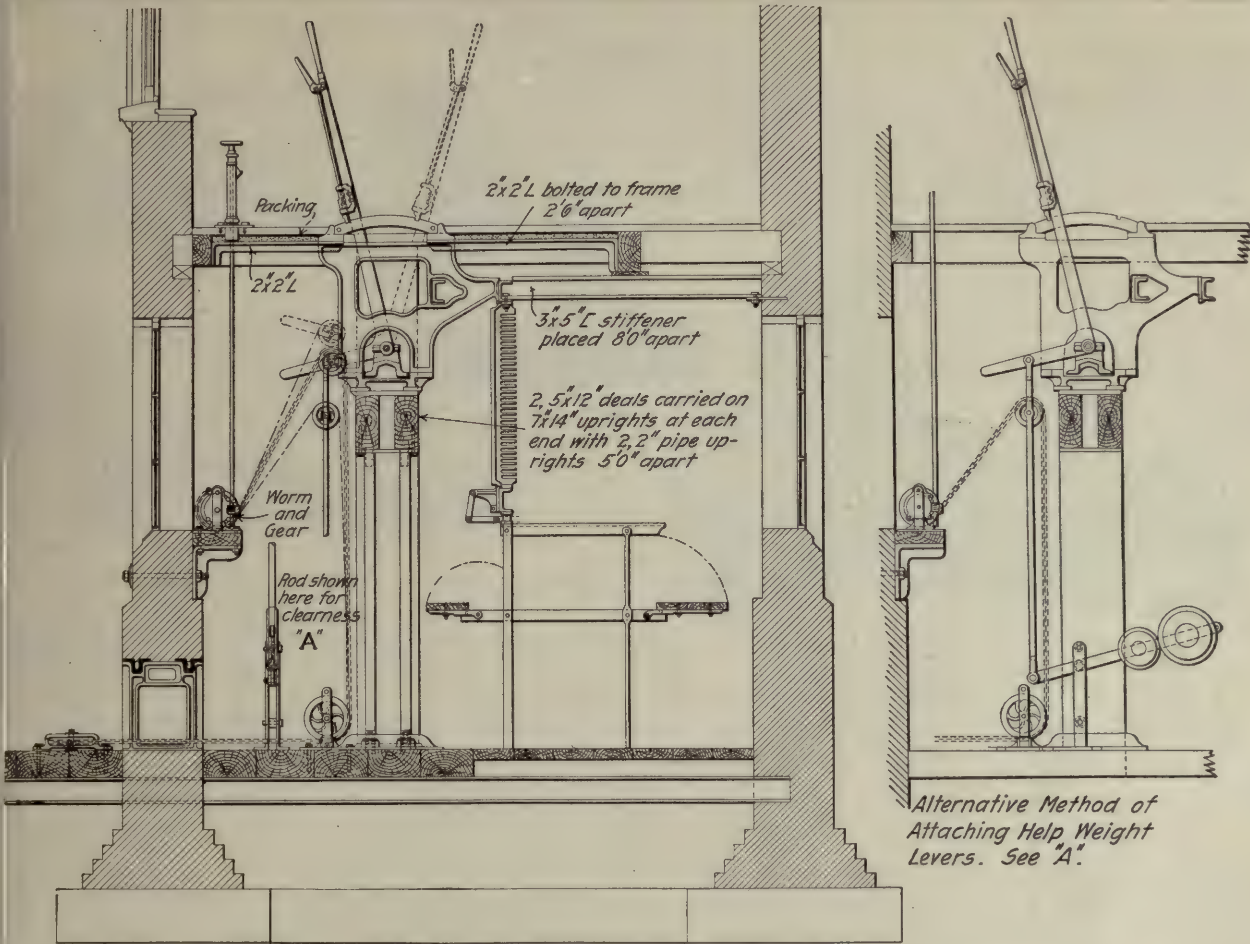
Figs. 1399-1408. Types of Single Vertical Chain Wheels.

Names of Parts of Wire Compensator; Figs. 1409-1410.

1 *Balance Lever Bracket*
2 *Half-Clamp*
3 *Pin*
4 *Bolt*
5 *Balance Lever*
6 *Counterweight*
7 *Link*
8 *Disengaging Lever*
9 *Chain Wheels*
10 *Side Bracket*
11 *Chain Wheel Pin*
12 *Bolts*
13 *Compensator Lever*
14 *Compensator Counterweight*
15 *Compensator Lever Bracket*
16 *Pin*
17 *Bolt*
18 *Front Half of Clamp*
19 *Back Half of Clamp*
20 *Clamp Bolt*



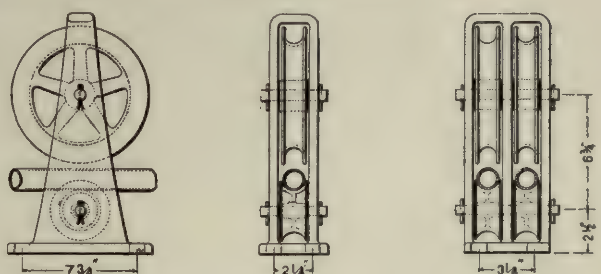
Figs. 1409-1410. Wire Compensator.

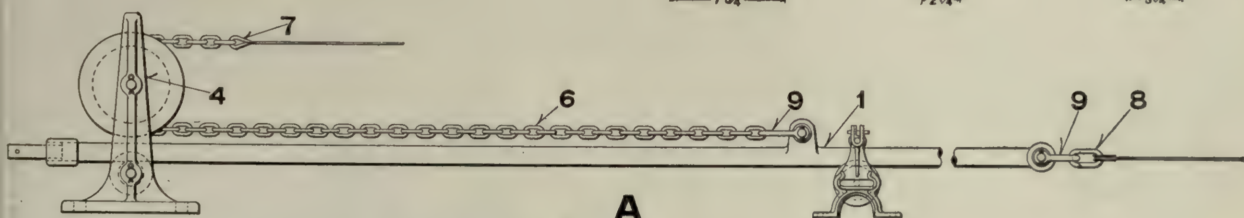


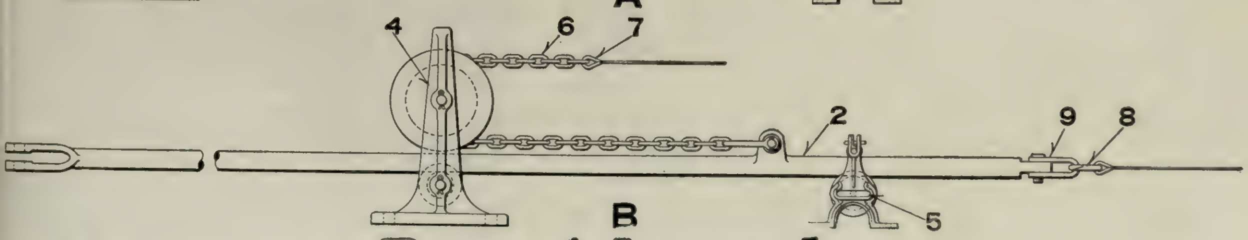
Figs. 1411-1412. Single Wire Compensator and Leadout Arrangements.

Names of Parts, Special Lugs and Attachments, for Changing from Pipe to Wire; Figs. 1413-1419.

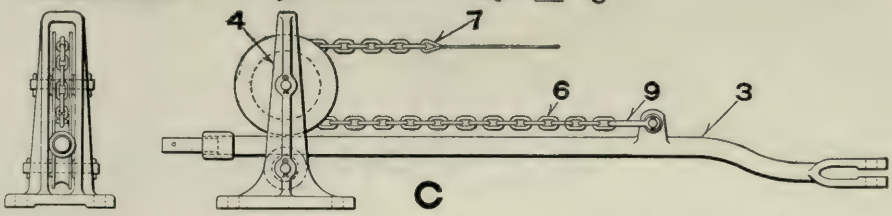
A *With Tang End Rod*
B *With Jaw*
C *With Jaw and Tang End; One Wire*
1 *Lug with Tang End and Eye*
2 *Lug with Jaw and Eye*
3 *Lug with Tang End and Jaw*







4 *One-Way Special Wheel*
5 *Pipe Carrier*
6 *Chain*
7 *Wire Eye*
8 *Split Link*
9 *Shackle*



Figs. 1413-1419. Special Lugs, Attachments and Wheels for Changing from Pipe to Wire Connections.

OIL PIPES.

Where it is necessary to run pipe lines under ground, as through a street, it is customary to enclose the one inch pipe in two inch or two and one-half inch galvanized pipe filled with oil. Stuffing boxes and plungers are provided at the ends to prevent the oil from escaping and cranks are mounted in oil boxes. The weight of the earth on the large pipe is usually sufficient to hold it in line, no foundations being necessary (Figs. 1425-1444). When it is desired to run wires under ground galvanized pipe is used and stuffing boxes (Figs. 1420-1424) are provided.

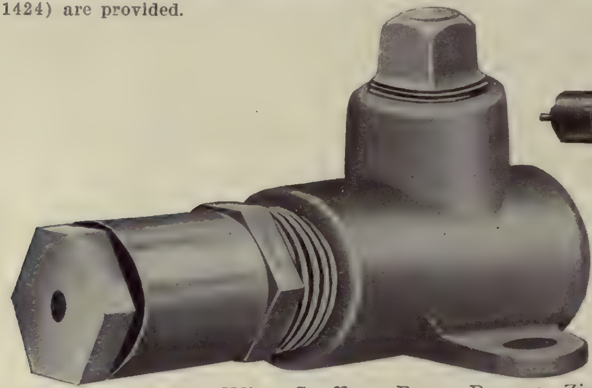
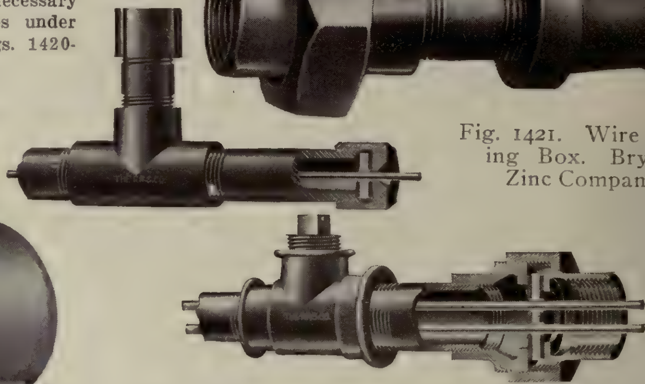


Fig. 1420. Single Wire Stuffing Box. Bryant Zinc Company.

Fig. 1421. Wire Packing Box. Bryant Zinc Company.



Figs. 1422-1423. Single and Double Wire Stuffing Boxes. Railroad Supply Company.

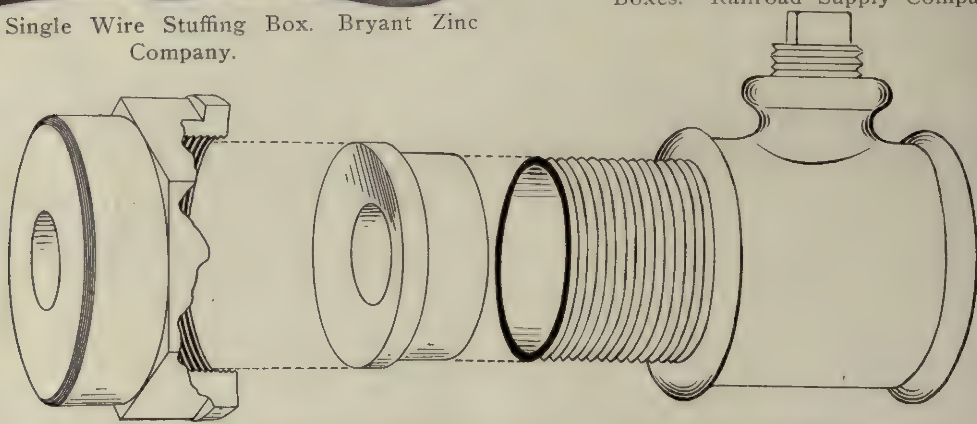
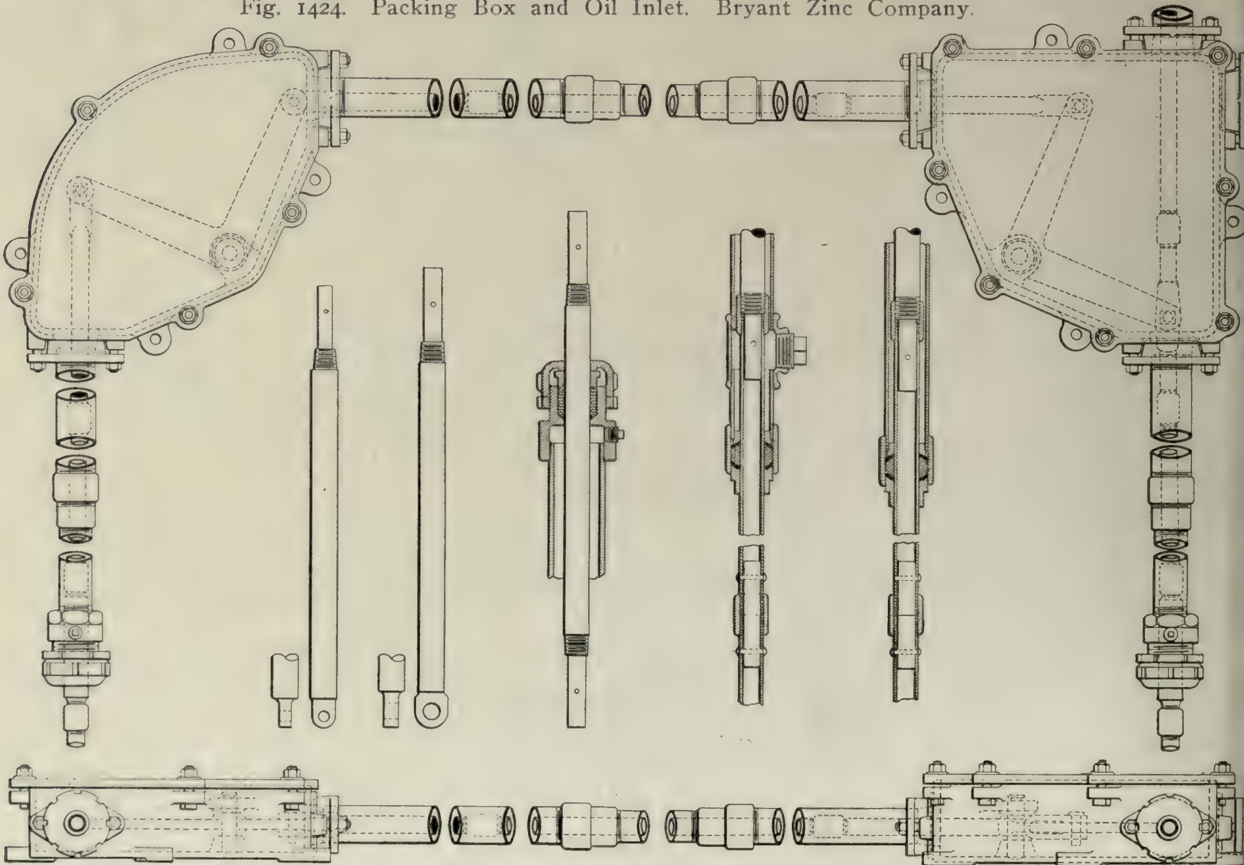


Fig. 1424. Packing Box and Oil Inlet. Bryant Zinc Company.

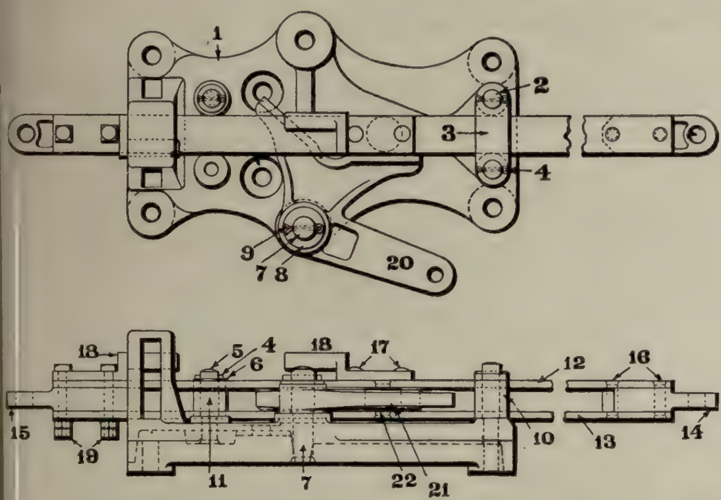


Figs. 1425-1444. Oil Crank Boxes, Oil Pipe, Stuffing Boxes and Plungers.

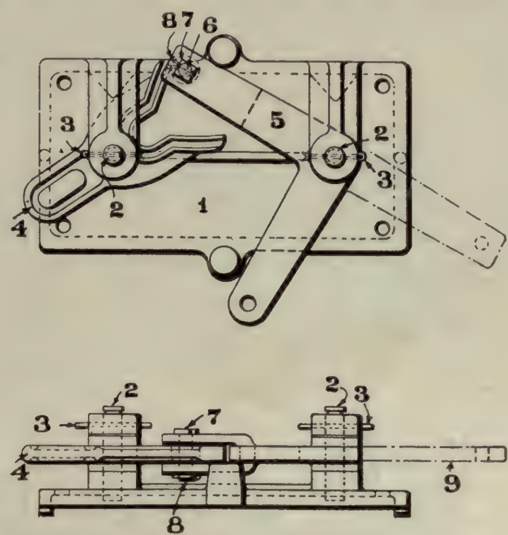
SWITCH OPERATING AND LOCKING MECHANISMS.

Next to the interlocking machine itself the most important part of an interlocking plant is the mechanism by which the switches are operated. The simplest arrangement that could be used would be a direct connection from the lever to the head rod of the switch. This would throw the switch, but, as there is considerable spring in the connection, it would give no assurance that the switch had entirely completed its movement. For this reason some form of locking is necessary. This is accomplished in two ways; by facing point locks and by switch and lock movements.

A facing point lock (Figs. 1459-1479) consists of a plunger casting, a plunger and a lock rod. The lock rod is attached to the movable part of the switch and passes through a slot in the plunger casting. The plunger is operated by a separate lever (interlocked with the switch lever) and moves through the plunger casting at right angles to the lock rod. When the



igs. 1445-1446. Switch and Lock Movement for Switch.



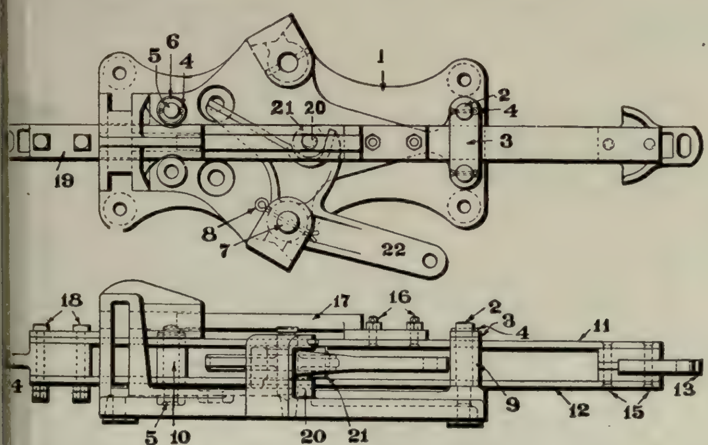
Figs. 1447-1448. Johnson Type Switch and Lock Movement.

Names of Parts of Switch and Lock Movement; Figs. 1445-1446.

1	*Base*	12	*Upper Slide Bar*
2	1" x 5" *Stud*	13	*Lower Slide Bar*
3	*Cap for Guide Rollers*	14	*Lug for Slide Bar*
4	¼" x 1¾" *Cotter*	15	*Lug for Slide Bar*
5	1" x 4" *Stud*	16	*Rivet*
6	*Washer*	17	*Rivet*
7	1¼" x 5" *Stud*	18	½" x 4¼" Bolt
8	*Washer*	19	*Bolt*
9	*Cotter*	20	*Escapement Crank*
10	*Guide Roller*	21	*Operating Roller*
11	*Guide Roller*	22	1" x 3" *Stud*

Names of Parts for Johnson Type Switch and Lock Movement; Figs. 1447-1448.

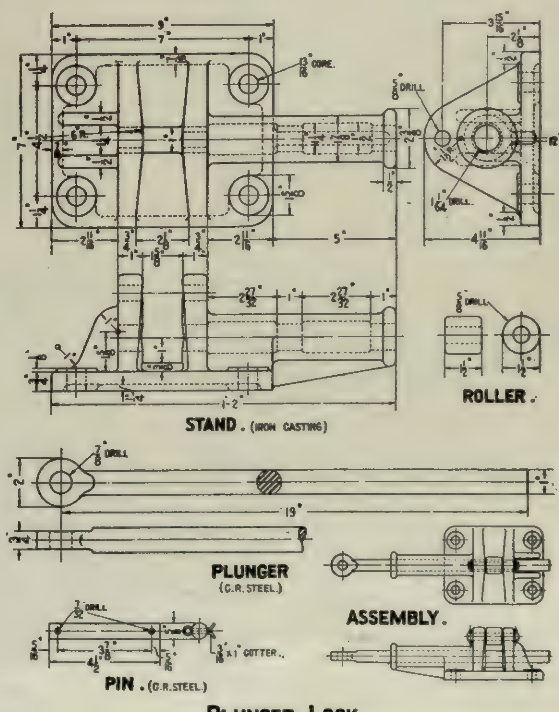
1 *Base*
2 *Pin*
3 *Cotter*
4 *Escapement Crank*
5 *Crank*
6 *Pin*
7 *Operating Roller*
8 *Cotter*
9 *Special T Crank*



gs. 1449-1450. Switch and Lock Movement for Derails, Locking One Way Only.

Names of Parts of Derail Switch and Lock Movement; Figs. 1449-1450.

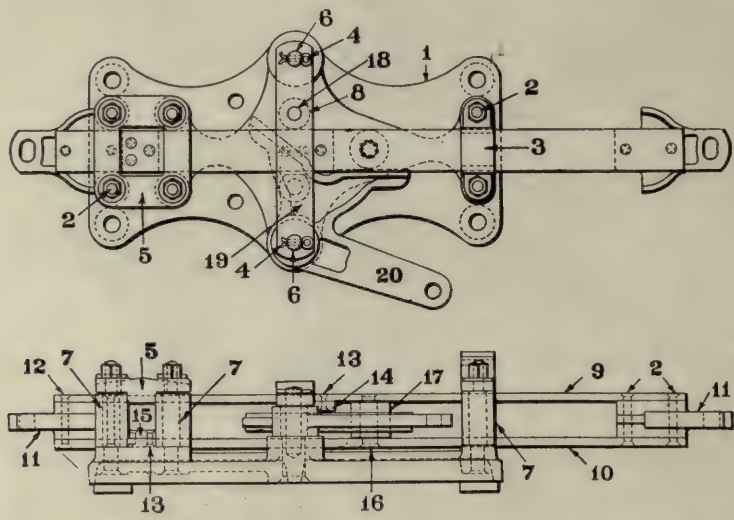
1	*Base*	12	*Lower Slide Bar*
2	*Stud*	13	*Slide Bar Lug*
3	*Cap for Guide Rollers*	14	*Slide Bar Lug*
4	*Cotter*	15	½" x 3" *Rivet*
5	*Stud*	16	*C. S. H. Bolt*
6	*Washer*	17	*Locking Plunger*
7	*Pin*	18	½" x 4¼" *Bolt*
8	*Cotter*	19	*Slide Bar Stop*
9	*Guide Roller*	20	¾" x 3" *Pin*
10	*Guide Roller*	21	*Operating Roller*
11	*Upper Slide Bar*	22	*Escapement Crank*



Figs. 1451-1456. R. S. A. Standard Plunger Lock.

switch is either fully normal or fully reversed, one or the other of two holes drilled in the lock rod is in line with the hole in the plunger casting through which the plunger moves, and when the lever which operates the plunger (known as the lock lever) is reversed, the plunger passes through the lock rod, thereby holding the switch firmly in place. Facing point locks are applied in two ways, known as inside connected (Figs. 1473-1474) and outside connected (Figs. 1475-1478 and 1479). In the former, the plunger casting is mounted on the head block between the rails and the head or bridle rod is used as lock rod. In the latter the plunger casting is mounted outside the rails and a separate rod (see Figs. 1526-1527 and 1534-1542) is attached to the head rod, or may be made part of it. Outside connected facing point locks are more extensively used because they are not liable to injury from dragging brake rigging, etc.

The use of facing point locks necessitates an additional lever in the machine and a separate line of connections. To save the cost of these, switch and lock movements (Figs. 1445-1452) are sometimes employed. A switch and lock movement consists essentially of a frame on which are mounted an operating bar, escapement crank, and guides for the operating bar and lock rod. To the operating bar are attached lugs or plungers for locking the switch by entering holes or notches in the lock rod, and a lug for driving the escapement crank, which actuates the throw rod and moves the switch. Normally one lug or plunger is engaged with the lock rod, holding the switch locked. When the operating rod is moved the first portion of its stroke withdraws the plunger or lug and unlocks the switch, the second portion actuates the escapement crank and throws the switch and the last portion inserts the other plunger or lug locking the switch. These plungers or lugs may be of different shapes or placed in such relation to each other that they cannot both enter the same notch or hole in the lock rod. Thus, should the throw rod become disconnected, the switch could not be falsely locked. For use at derails, where it is necessary to lock only one way, a special form of switch and lock movement may be used (Figs. 1449-1450). Another form of movement (Figs. 1447-1448) requires a separate plunger casting, having two plungers entering from opposite ends (Figs. 1461-1462), known as a duplex lock, connected directly to the pipe line. A switch layout with switch and lock movement may be seen in Figs. 1480-1481. The weak point of the switch and lock movement is the small amount of motion available for locking the switch. Consequently, owing to the spring and lost motion in the connections, a lever might be fully reversed without causing the movement to complete its stroke. Also the one pipe line becoming



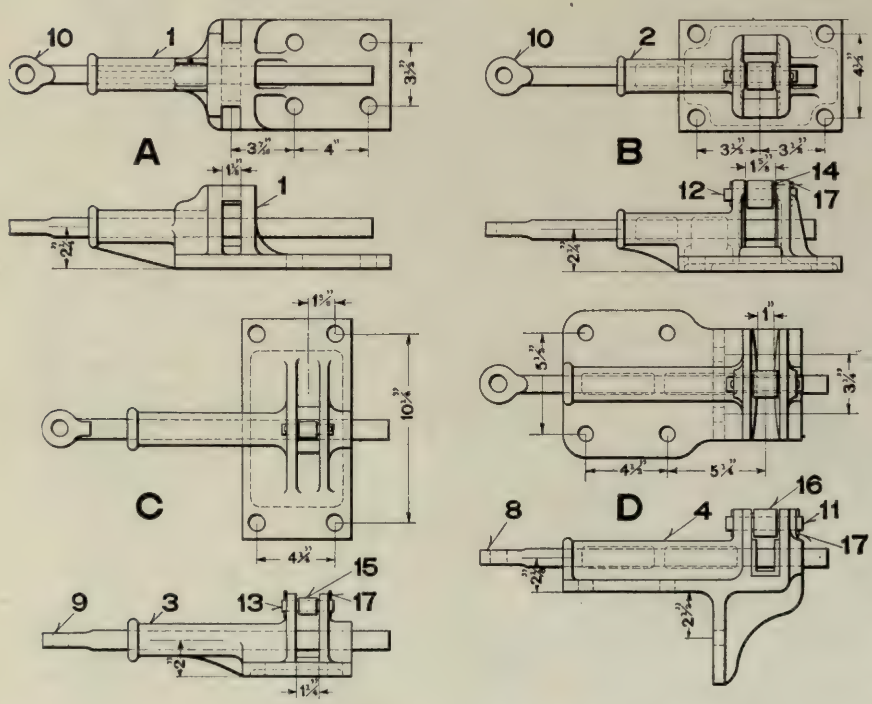
Figs. 1457-1458. Switch and Lock Movement Using Notched Lock Rod.

Names of Parts of Switch and Lock Movement; Figs. 1457-1458

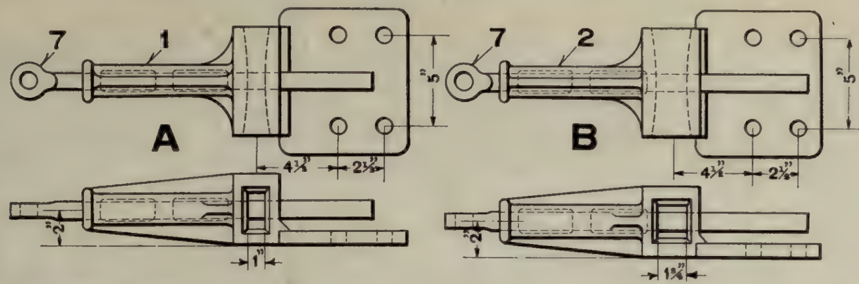
1 *Base*
2 *Stud*
3 *Cap for Guide Rollers*
4 *Cotter*
5 *Yoke for Guide Rollers and Lock Rod*
6 *Stud*
7 *Guide Roller*
8 *Center Guide Roller*
9 *Upper Slide Bar*
10 *Lower Slide Bar*
11 *Lug for Slide Bar*
12 *Rivet*
13 *Rivet*
14 *Upper Locking Dog*
15 *Lower Locking Dog*
16 *Pin*
17 *Operating Roller*
18 *Pin*
19 *Cap for Crank and Center Roller*
20 *Escapement Crank*

Names of Parts of Plunger Locks; Figs. 1459-1466.

A *Single Plunger Lock*
B *Double Plunger Lock Roller Bearing*
C *Single Plunger Lock, Roller Bearing, Wide Base*
D *Left Hand Single Plunger Lock, Roller Bearing*
1 *Plunger Casting for A*
2 *Plunger Casting for B*
3 *Plunger Casting for C*
4 *Plunger Casting for D*
8 *Plunger for D*
9 *Plunger for C*
10 *Plunger for A and B*
11 *Roller Pin for D*
12 *Roller Pin for B*
13 *Roller Pin for C*
14 *Roller for B*
15 *Roller for C*
16 *Roller for D*
17 *Cotter*

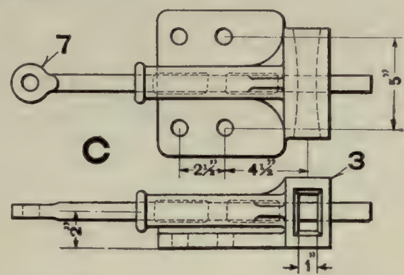


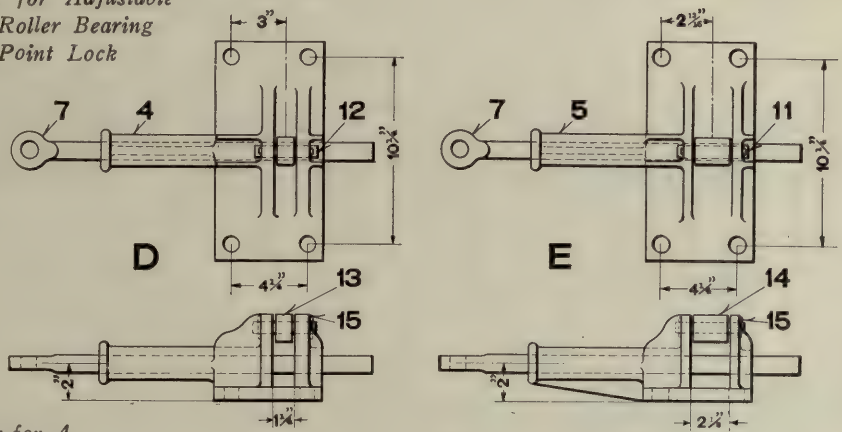
Figs. 1459-1466. Plunger Locks.



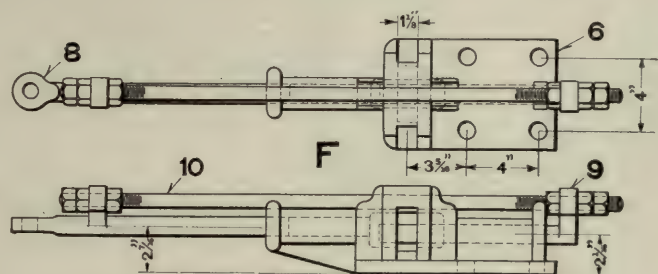
Names of Parts of Plunger Locks; Figs. 1467-1478.

A *Single Plunger Locking Stand*
B *Double Plunger Locking Stand for Adjustable Lock Rod*
C *Left Hand Single Plunger Locking Slide*
D *Single Plunger Locking Stand, Wide Base, Roller Bearing*
E *Double Plunger Locking Stand, Wide Base, for Adjustable Lock Rod, Roller Bearing*
F *Duplex Facing Point Lock*





1 *Plunger Casting for A*
2 *Plunger Casting for B*
3 *Plunger Casting for C*
4 *Plunger Casting for D*
5 *Plunger Casting for E*
6 *Plunger Casting for F*
7 *Plunger*
8 *Right Hand Plunger for F*
9 *Left Hand Plunger for F*
10 *Yoke Rod*
11 *Roller Pin*
12 *Roller Pin*
13 *Roller for D*
14 *Roller for E*
15 *Cotter*



Figs. 1467-1478. Plunger Locks.

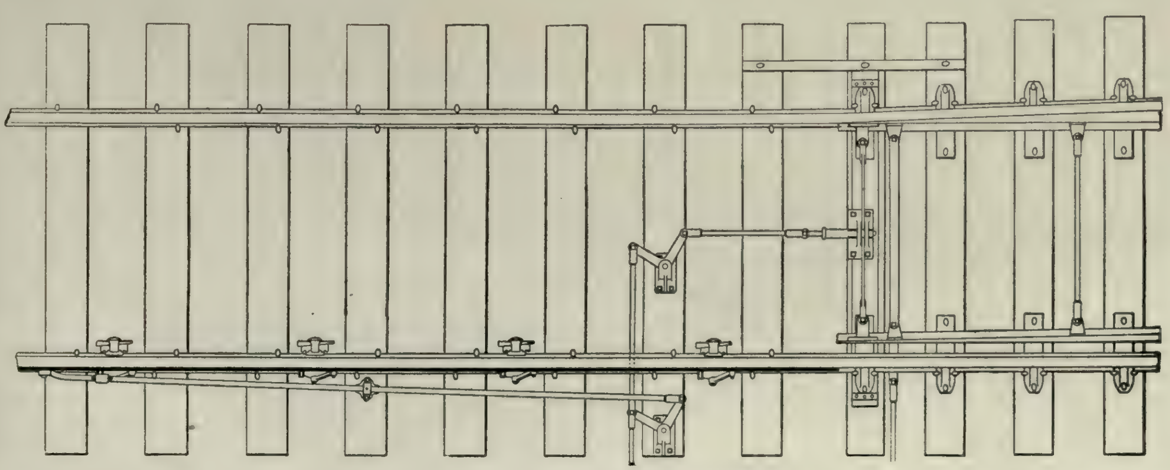


Fig. 1479. Inside Connected Facing Point Lock and Switch Fittings. Detector Bar Ahead of Points.

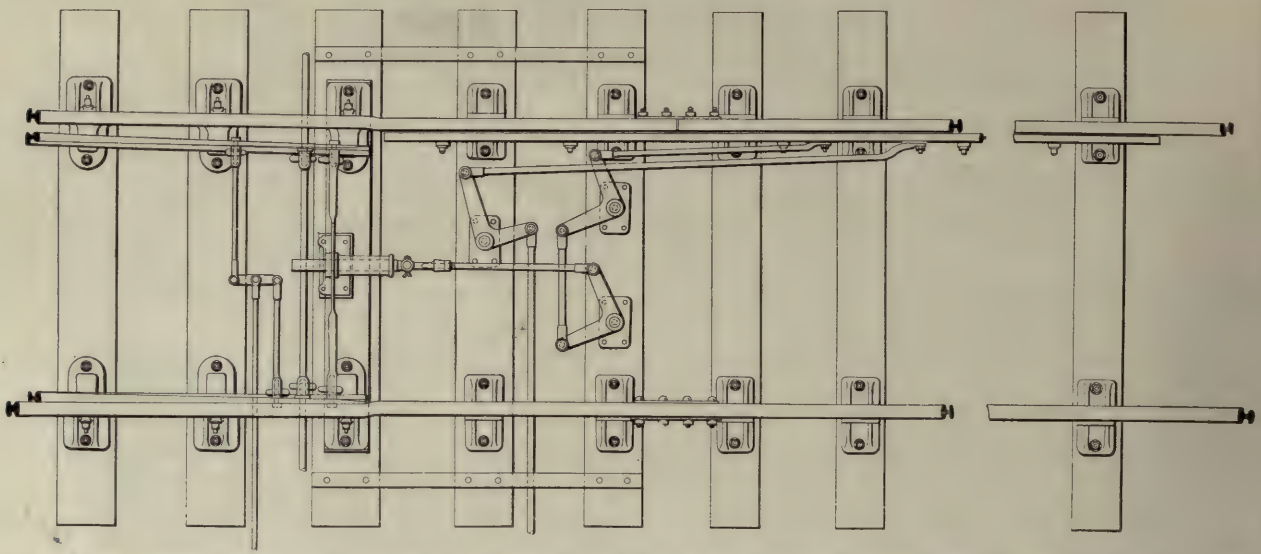


Fig. 1480. Inside Connected Facing Point Lock, Throw Rod and Inside Parallel Bar (Detector Bar). Great Western Railway of England.

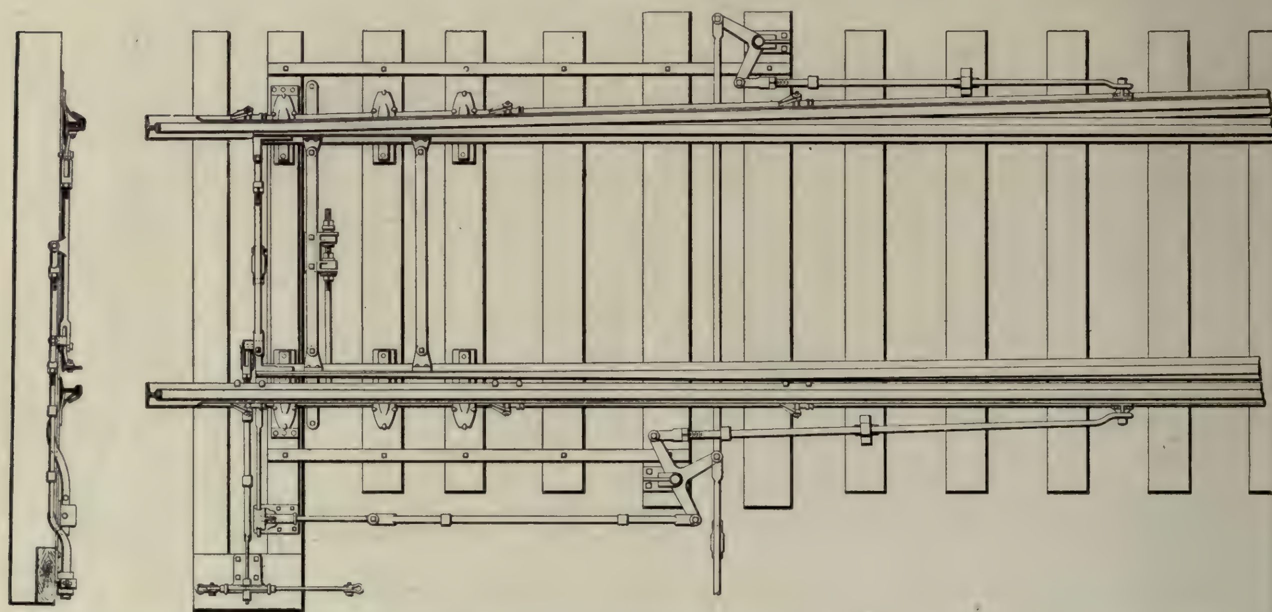


Fig. 1481. Outside Connected Facing Point Lock and Switch Connections, with Bolt Lock. Two Detector Bars Behind the Points.

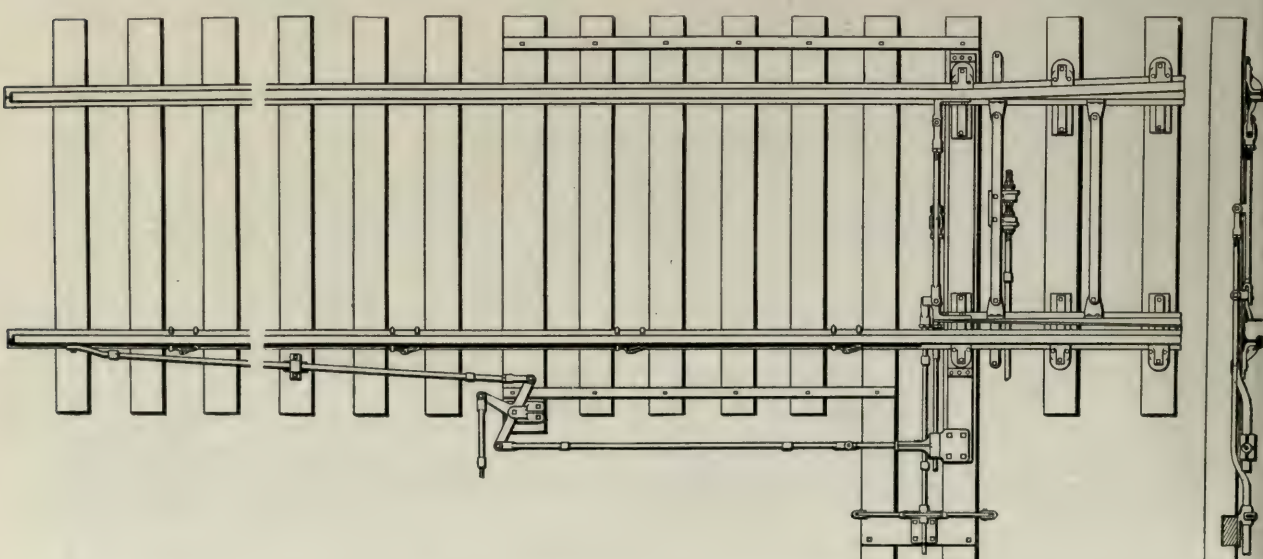


Fig. 1482. Outside Connected Facing Point Lock and Switch Fittings, with Bolt Lock. Detector Bar Ahead of the Points.

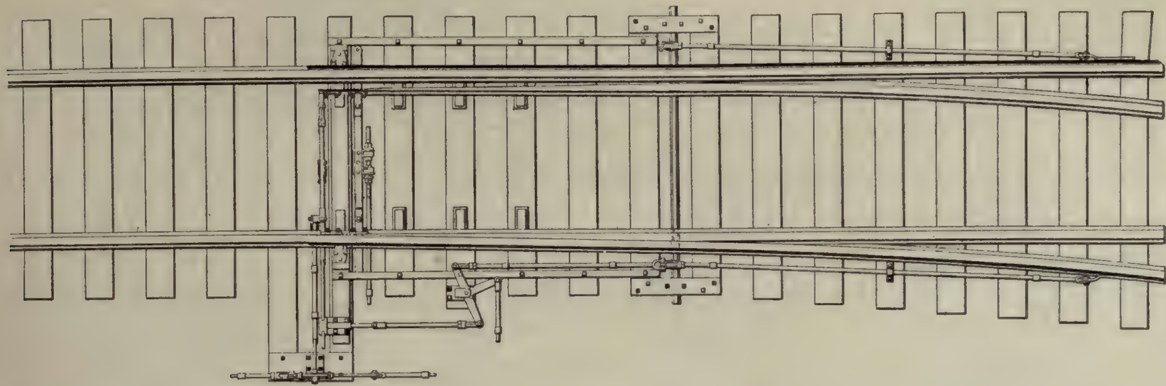


Fig. 1483. Outside Connected Facing Point Lock and Switch Fittings, with Bolt Lock. Two Detector Bars Behind Points, Moved by a Rocker Shaft.

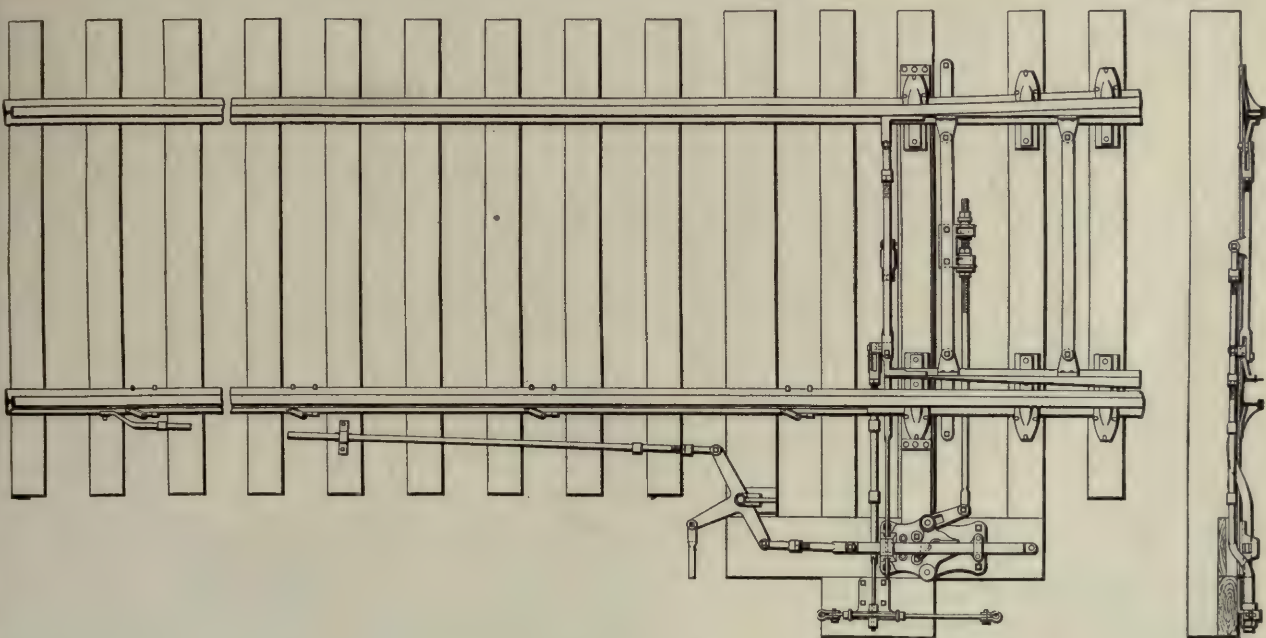


Fig. 1484. Switch and Lock Movement, Switch Fittings and Bolt Lock. Detector Bar Ahead of Points.

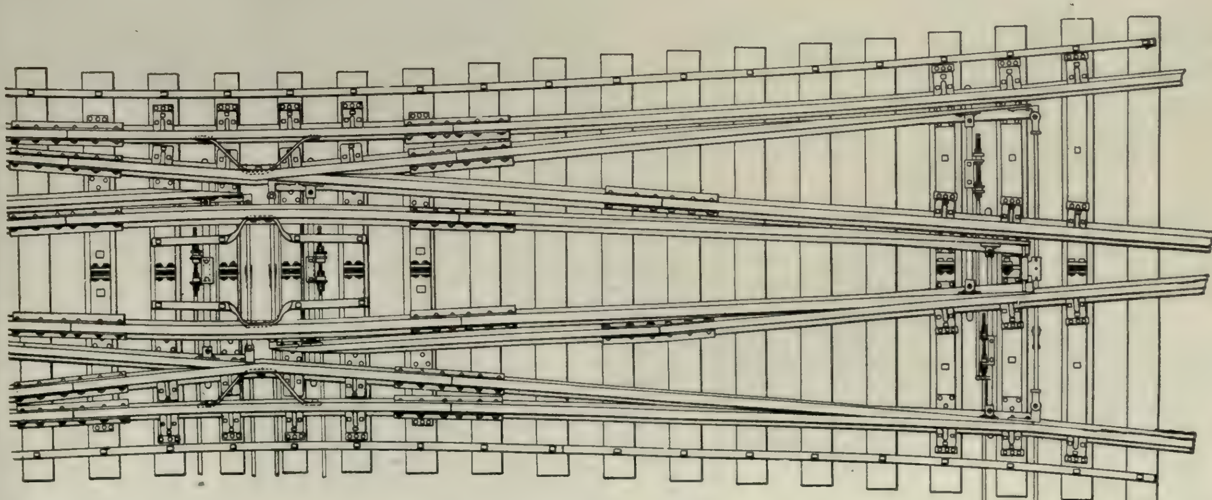
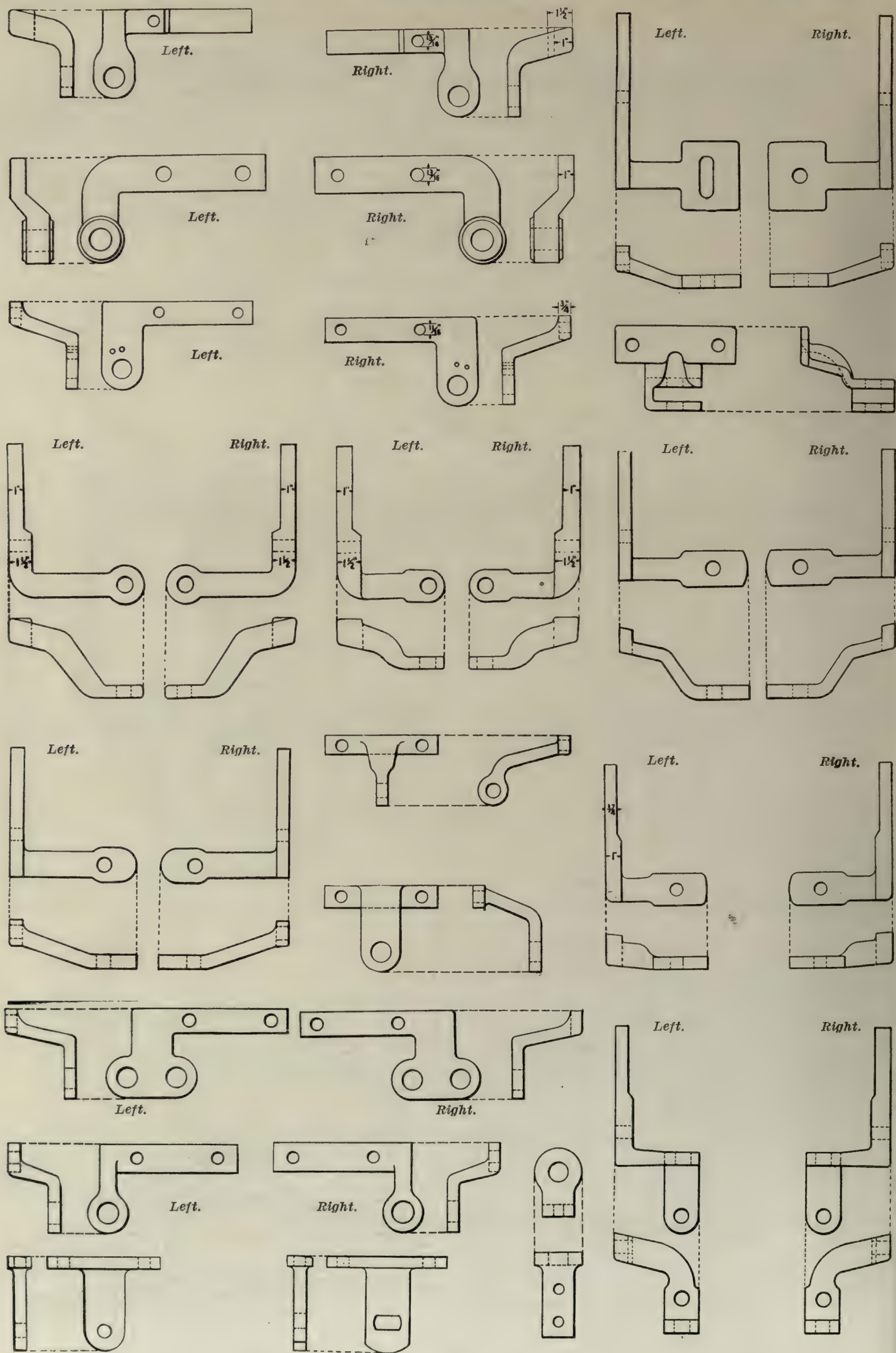
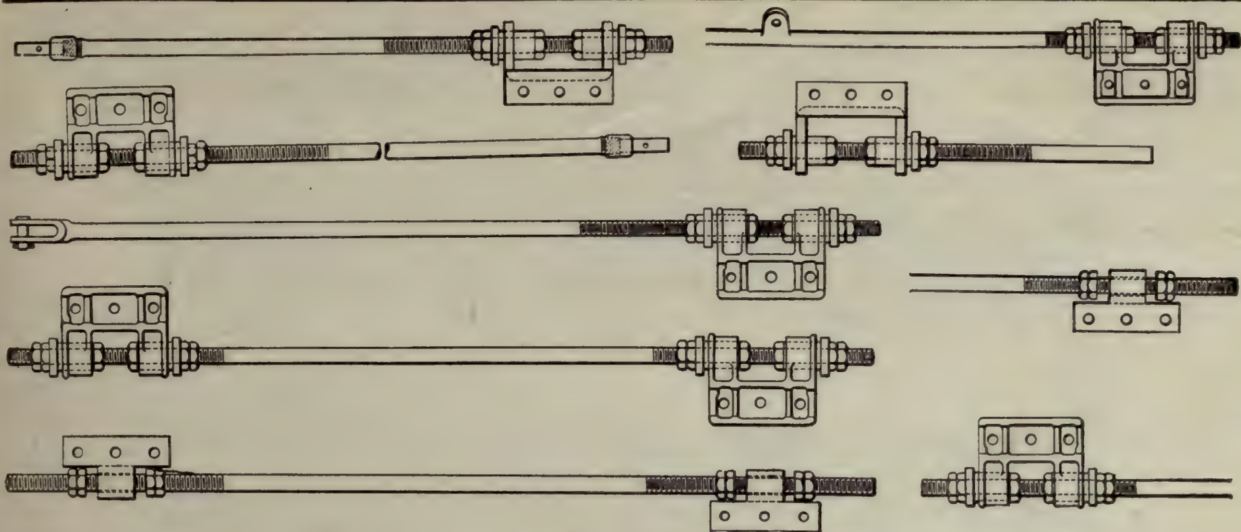


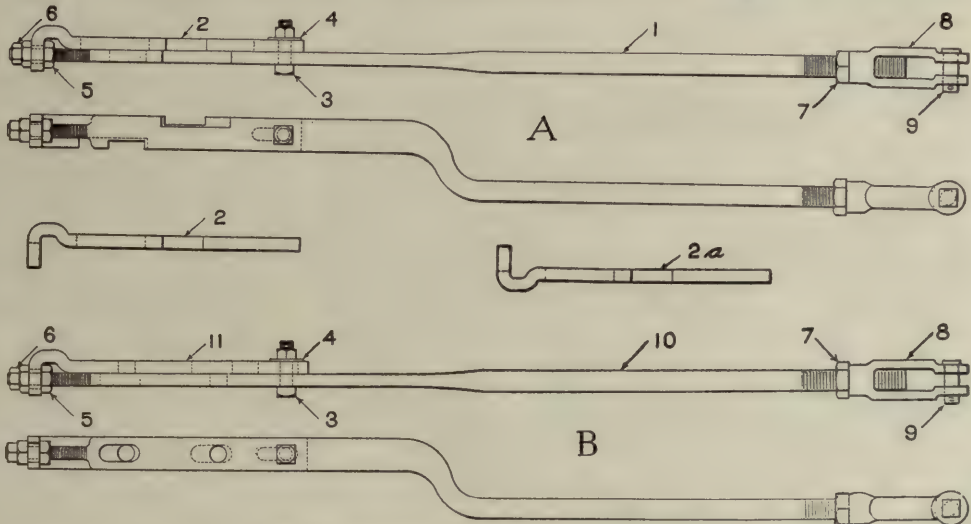
Fig. 1485. Method of Plating and Tying Double Slip Switch, with Movable Point Frogs. Detector Bars Not Shown; Tie Plates Insulated. Long Island Railroad.



Figs. 1486-1512. Switch Point Lugs.



Figs. 1513-1521. Throw Rods and Switch Adjustments.



Figs. 1522-1527. Adjustable Lock Rods.

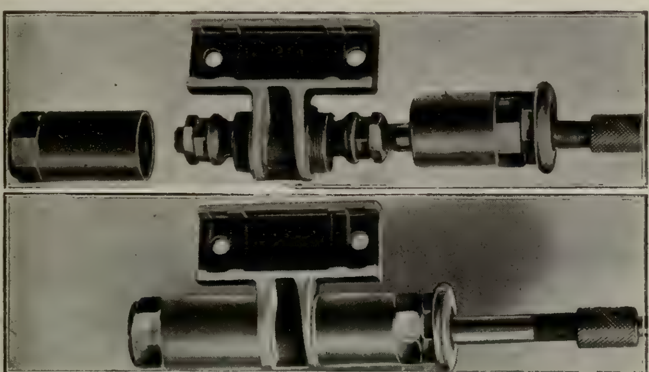


Fig. 1528. Bossert Switch Adjuster, Open and Closed. W. F. Bossert Manufacturing Company.

Names of Parts of Adjustable Lock Rods; Figs. 1522-1527.

A *Adjustable Lock Rod for Switch and Lock Movement. Figs.* 1457-1458.
B *Adjustable Lock Rod for Facing Point Lock*
1 *Lock Rod*
2 *Adjusting Lock Plate, Right Hand*
2a *Adjusting Lock Plate, Left Hand*
3 *¾" x 2¾" Bolt and Nut*
4 *¾" Washer*
5 *Adjusting Sleeve*
6 *Jam Nut*
7 *Jam Nut*
8 *1¼" Screw Jaw*
9 *⅞" x 2⅜" Pin and Cotter*
10 *Lock Rod*
11 *Adjustable Locking Plate*

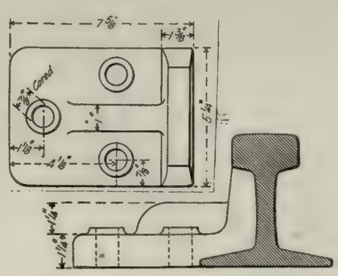


Fig. 1529. Cast-Iron Rail Brace for 100-lb. Rail. Long Island Railroad.

Fig. 1530. Rail Brace. The Cleveland Frog & Crossing Company.

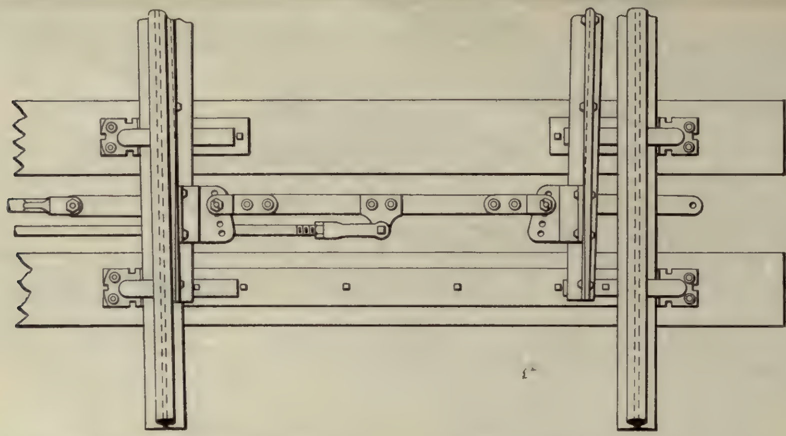
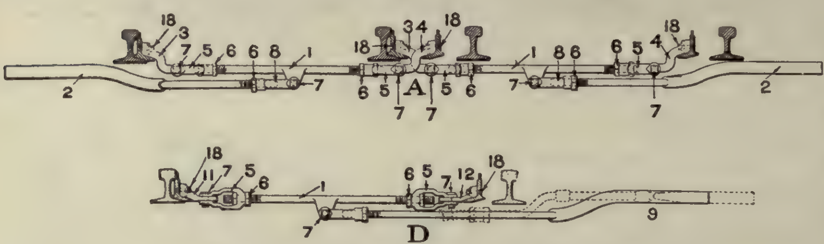


Fig. 1531. Switch Adjustment. Southern Pacific-Union Pacific.

Names of Parts of Front and Lock Rods; Figs. 1532-1533.

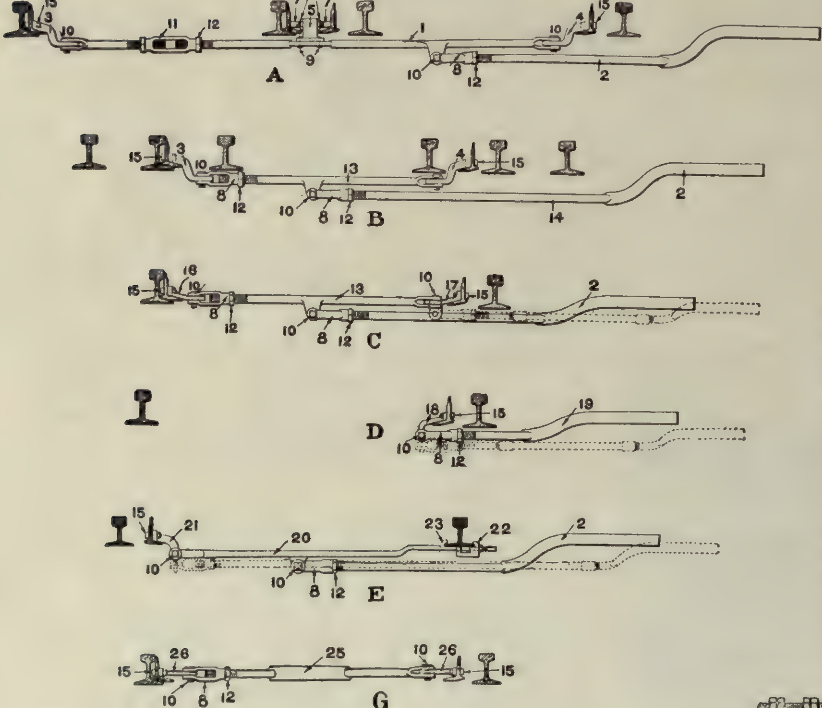
- A *Front and Lock Rod for Double Slip Switch*
- D *Front and Lock Rod for Switch with Switch and Lock Movement*
- 1 *Front Rod*
- 2 *Lock Rod*
- 3 *Left Hand Point Lug*
- 4 *Right Hand Point Lug*
- 5 1¼" *Screw Jaw*
- 6 1½-in. *Jam Nut*
- 7 ⅞" x 2⅜" *Pin and Cotter*
- 8 1¼-*in. Screw Jaw*
- 11 *Left Hand Point Lug*
- 12 *Right Hand Point Lug*
- 18 ⅝" x 2⅜" *C. S. H. Bolt*



Figs. 1532-1533. Front and Lock Rods.

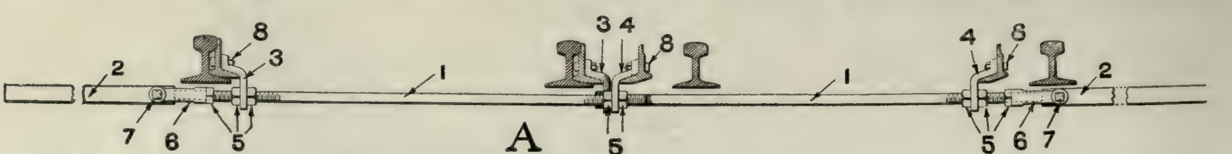
Names of Parts of Front and Lock Rods; Figs. 1534-1539.

- A *Front and Lock Rod for Double Slip Switch*
- B *Front and Lock Rod for Movable Point Frog*
- C *Front and Lock Rod for Single Switch*
- D *Lock Rod for Derail*
- E *Front and Lock Rod for Derail*
- G *Front and Lock Rod Combined for Inside Connected Facing Point Lock*
- 1 *Front Rod with Turnbuckle*
- 2 *Lock Rod*
- 3 *Left Hand Point Lug*
- 4 *Right Hand Point Lug*
- 5 *Point Separator*
- 6 1-*in. Jam Nut*
- 7 1-*in. Adjusting Screw*
- 8 1¼-*in. Screw Jaw*
- 9 ⅝" x 1⅜" *Rivet*
- 10 ⅞" x 2⅜" *Pin and Cotter*
- 11 *Turnbuckle*
- 12 1¼-*in. Jam Nut*
- 13 *Front Rod*
- 14 *Lock Rod*
- 15 ⅝" x 2⅜" *Bolt*
- 16 *Left Hand Point Lug*
- 17 *Right Hand Point Lug*
- 18 *Right Hand Point Lug*
- 19 *Lock Rod*
- 20 *Front Rod*
- 21 *Left Hand Point Lug*
- 22 *Guide Clip*
- 23 *Hook Bolt*
- 25 *Front and Lock Rod*
- 26 *Right or Left Hand Point Lug*



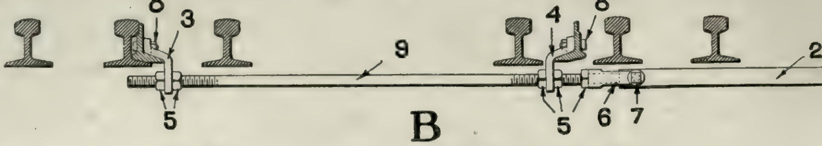
Figs. 1534-1539. Front and Lock Rods.

Fig. 1540. Special Front Rod.



Names of Parts of Front and Lock Rods; Figs. 1541-1542.

- A *Front and Lock Rods for Double Slip Switch*
- B *Front and Lock Rods for Movable Point Frog*
- 1 *Front Rod*
- 2 *Lock Rod*
- 3 *Left Hand Single Point Lug*
- 4 *Right Hand Single Point Lug*
- 5 1¼-*in. Jam Nut*



Figs. 1541-1542. Front and Lock Rods.

- 6 1¼-*in. Screw Jaw*
- 7 ⅞" x 2⅜" *Pin and Cotter*
- 8 ⅝" x 2⅜" *Bolt*
- 9 *Front Rod*

disconnected might cause a dangerous condition at the switch without being discovered at once by the signalman; whereas, with the facing point lock, if the pipe line which throws the switch should become disconnected, the signalman would be very likely to discover this, and remedy it before any train could pass over the switch.

have fixed notches or may be adjustable (Figs. 1522-1527).

In order to hold switch points and stock rails securely in place it is necessary to brace the rails at the switch; also one or more tie plates extending across the tracks are fastened to the ties. Fig. 1484 shows these fittings applied to a double slip and movable point frog. Rail braces are shown in Figs.

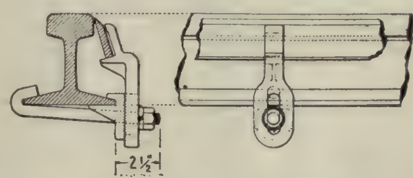
Figs. 1543-1544. Rail Clips, Detector Bar Stops and Detector Bars. The Union Switch & Signal Company.

Names of Parts for Detector Bars, Stops, Guides and Rail Clips; Union Switch & Signal Company; Figs. 1543-1544.

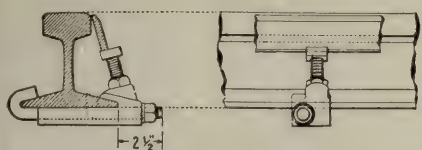
1 *Rail Clip, Model* 1
2 *Rail Clip, Model* 2
3 *Rail Clip, Model* 3
4 *Rail Clip, Model* 4
13 *Adjustable Stop and Guide*
14 *Adjustable Stop with Hook Bolt*
15 *Adjustable Stop with Hook or Web Bolt*

Figs. 1545-1546. Detector Bar Stop and Guide, to be Fastened to the Tie.

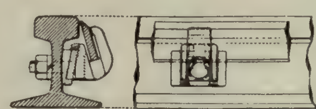
Figs. 1547-1548. Detector Bar Stop, Bolted Through Web of Rail.



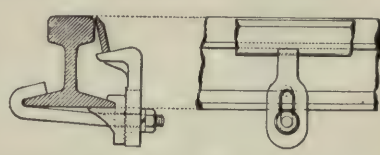
Figs. 1549-1550. Adjustable Detector Bar Stop and Guide, Clamped to Base of Rail.



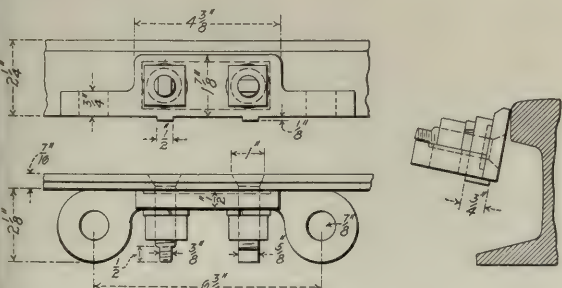
Figs. 1551-1552. Adjustable Detector Bar Stop, Clamped to Base of Rail.



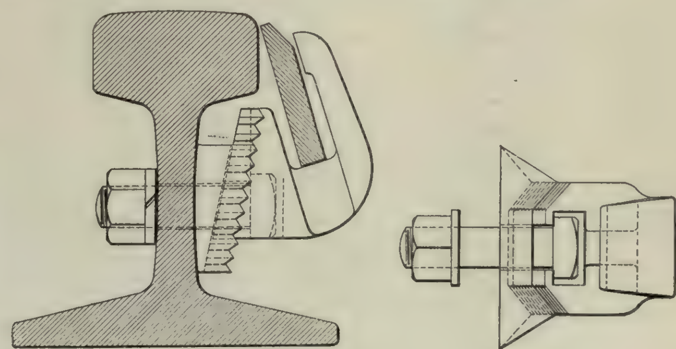
Figs. 1553-1554. Detector Bar Stop and Guide, Bolted Through Web of Rail.



Figs. 1555-1556. Adjustable Detector Bar Stop, Clamped to Base of Rail.



Figs. 1557-1559. Malleable Iron Detector Bar Driving Piece. Michigan Central.



Figs. 1560-1561. Detector Bar Guide and Stop

In order to allow for lost motion and future adjustment, the throw in the pipe line which moves the switch is usually made greater than that of the switch itself. To provide for this over-stroke, switch adjustments or "cages" (Figs. 1513-1521) are used. The throw rod is threaded for a considerable distance and passes through thimbles in the "cage." Nuts are checked up against each side of the thimbles which in turn engage the "cage" and throw the switch. Lock rods may

1528-1530. This construction can be applied equally well to a single switch. In the drawing the rods and plates are shown insulated for track circuits. The plates are made of one-half in. by six in. iron.

DETECTOR BARS.

To prevent signalmen from throwing switches under moving trains detector bars are employed. A detector bar is a piece of

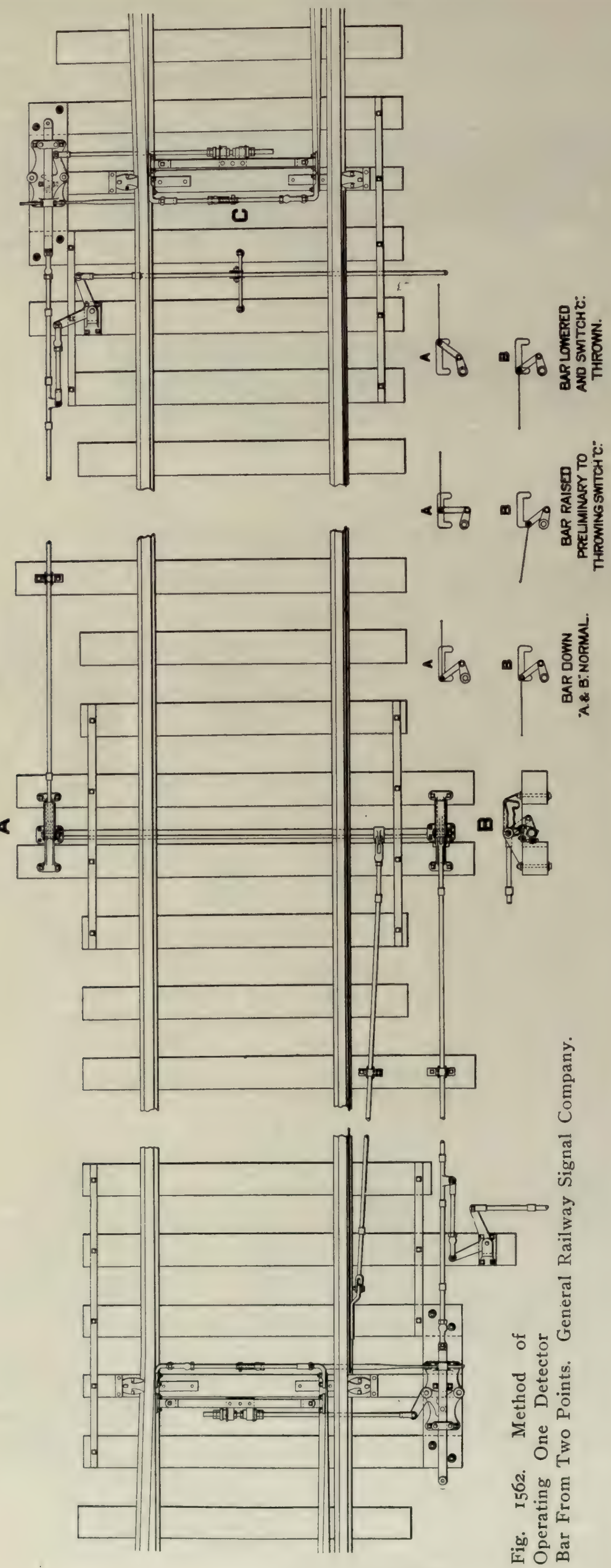


Fig. 1562. Method of Operating One Detector Bar From Two Points. General Railway Signal Company.

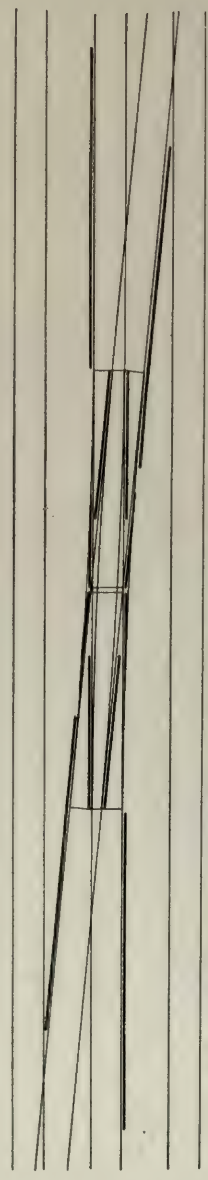


Fig. 1563. Detector Bars, with Double Slip Switch. New York Central & Hudson River.

Fig. 1566. Standard Detector Bar Layout at Cross-over. New York Central & Hudson River.

Fig. 1567. Standard Detector Bar Layout at Cross-over on Curve; Bar Ahead of Points. New York Central & Hudson River.

Fig. 1565. Standard Detector Bar Layout at Cross-over; Bars Behind Points. New York Central & Hudson River.

Fig. 1564. Standard Detector Bar Layout at Cross-over on Curve; Bars Behind Points. New York Central & Hudson River.

New York Central Standard.

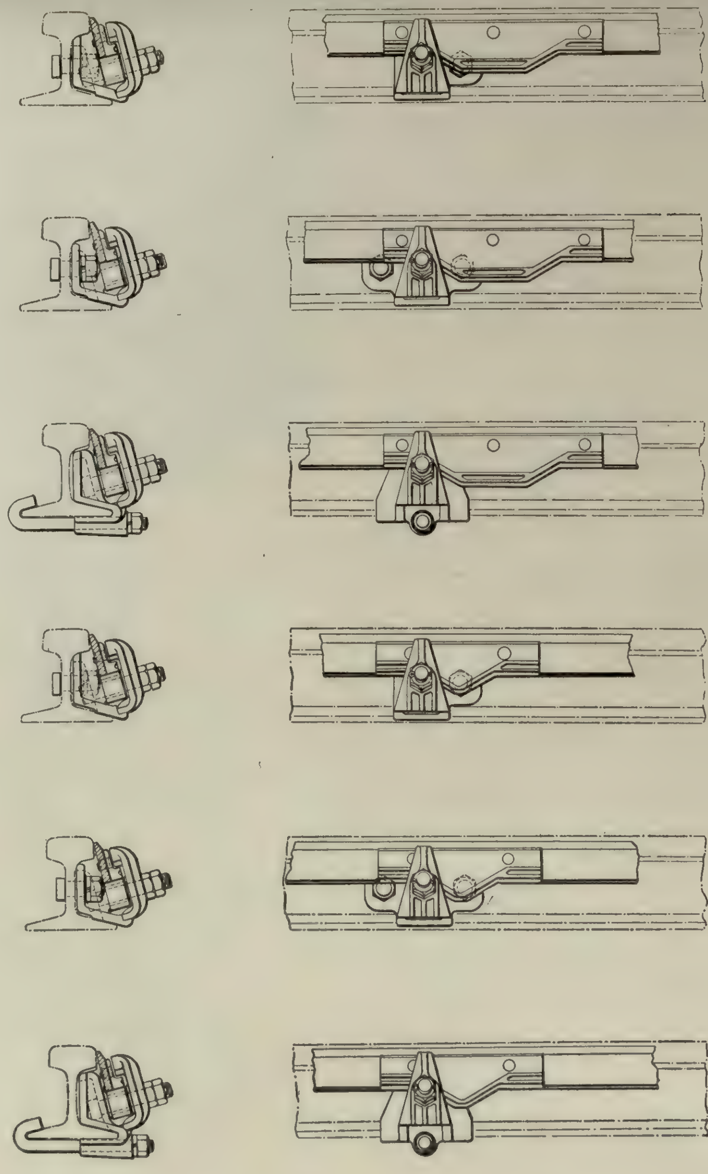
New York Central Standard.

Union Elevated Standard.

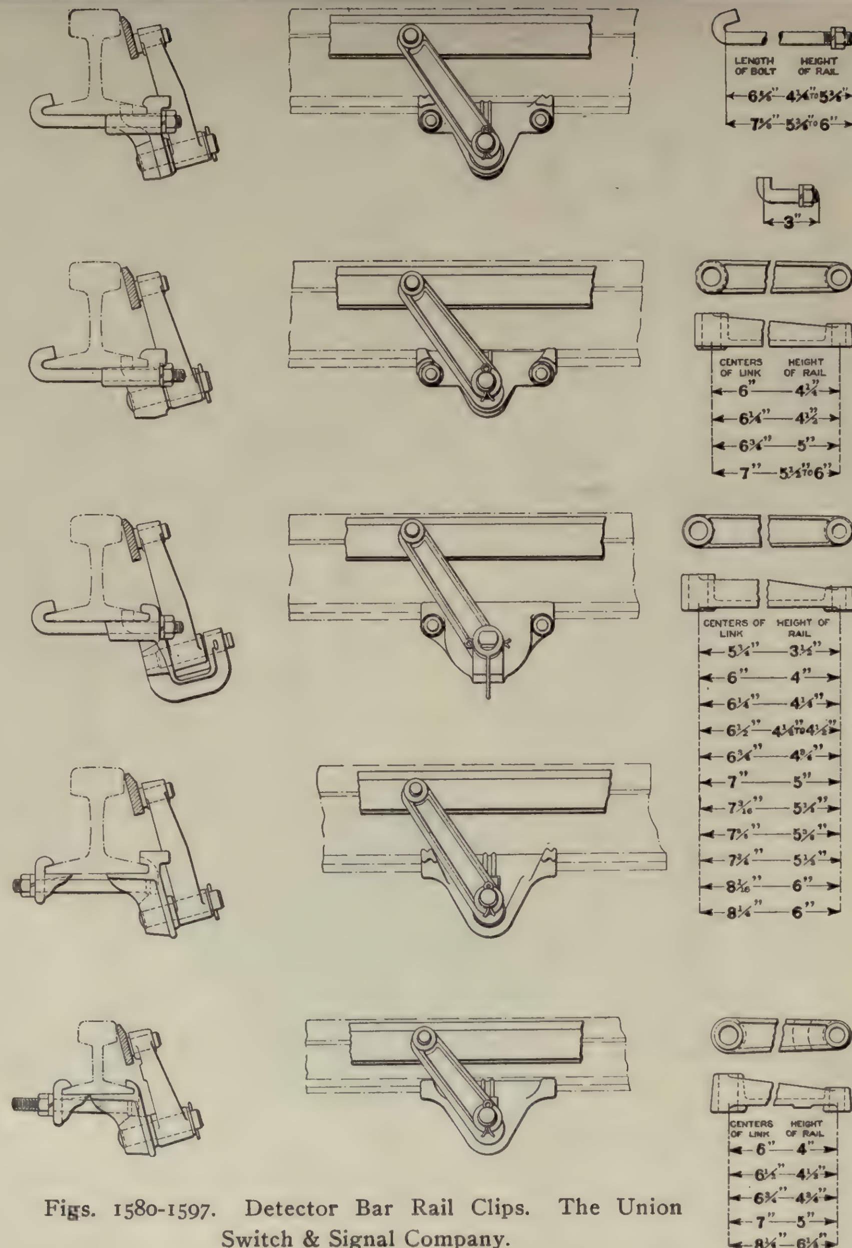
New York Central Standard.

New York Central Standard.

Union Elevated Standard.

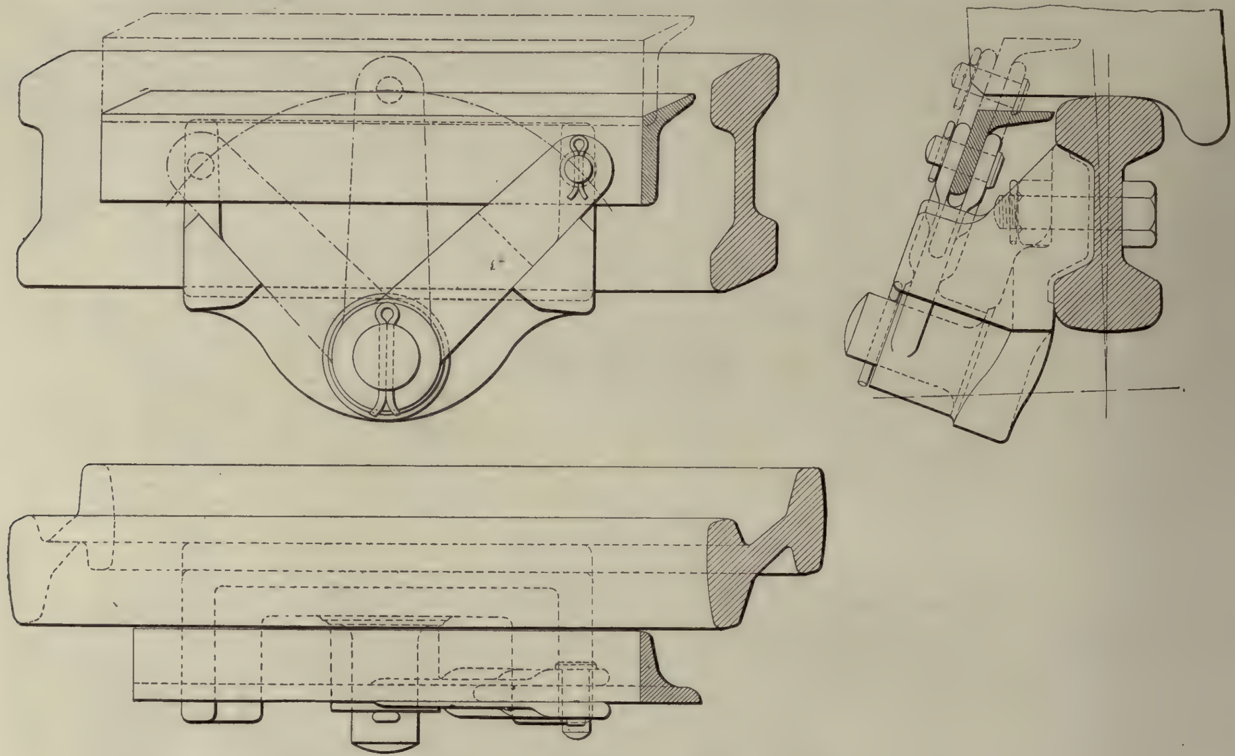


Figs. 1568-1579. Motion Plate Detector Bar Rail Clips.

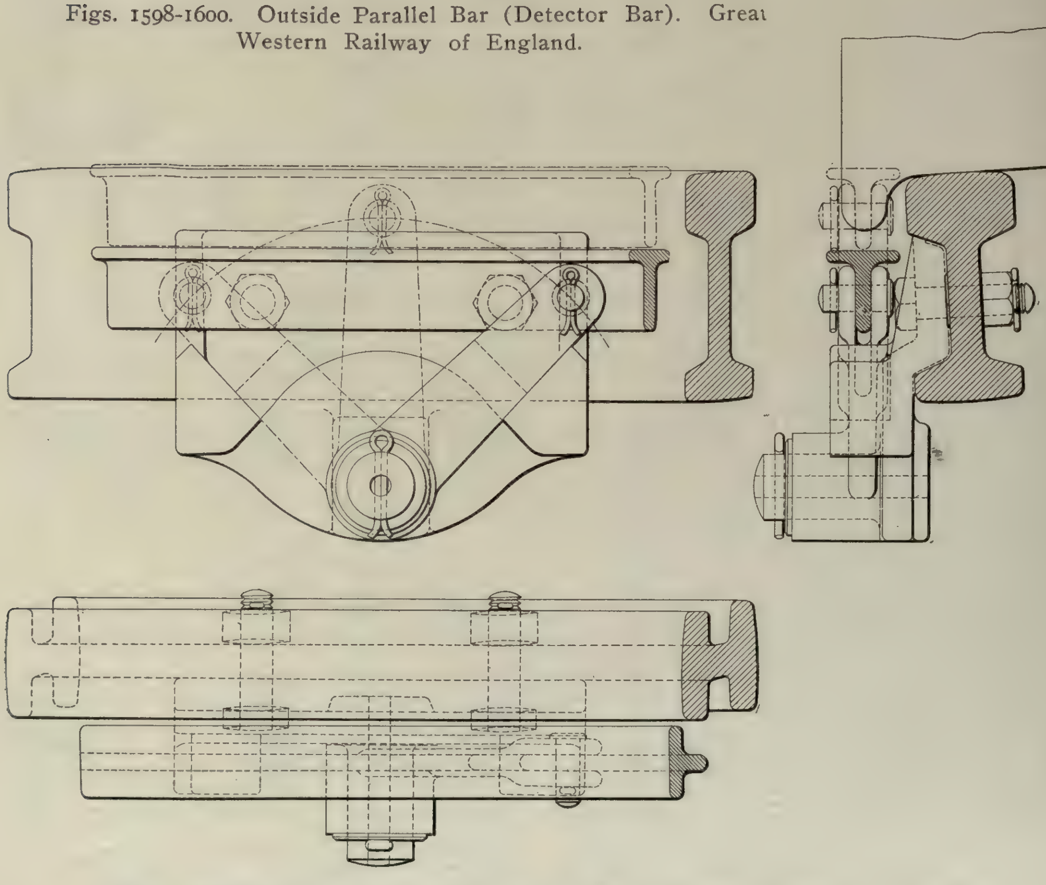


Figs. 1580-1597. Detector Bar Rail Clips. The Union Switch & Signal Company.

iron lying along the rail. It is held in place by clips and guides (Figs. 1545-1597), so that whenever it is moved lengthwise the top of it rises above the head of the rail. With such an arrangement it will be seen that if an attempt is made to move the bar while one or more wheels of a train are on the track at that point, the bar will strike against the wheels and cannot be thrown. Detector bars are made longer than the maximum distance between the wheels of a car in order that they may not rise between trucks. The bar is actuated by the same rod that operates the plunger of a facing point lock, or by the operating rod of a switch and lock movement. Therefore the bar must rise at the same time the switch is being unlocked. Various arrangements of detector bars at switches are shown in Figs. 1480-1485 and 1562-1567. The bar should always be put on the high side of a curve as centrifugal force tends to throw the wheels of a train toward that side. Where a bar cannot be placed ahead of a switch, two bars must be used as shown in Figs. 1480-1483, 1564-1567, one on each track, thereby insuring that it will be impossible to unlock the switch when either track is



Figs. 1598-1600. Outside Parallel Bar (Detector Bar). Great Western Railway of England.



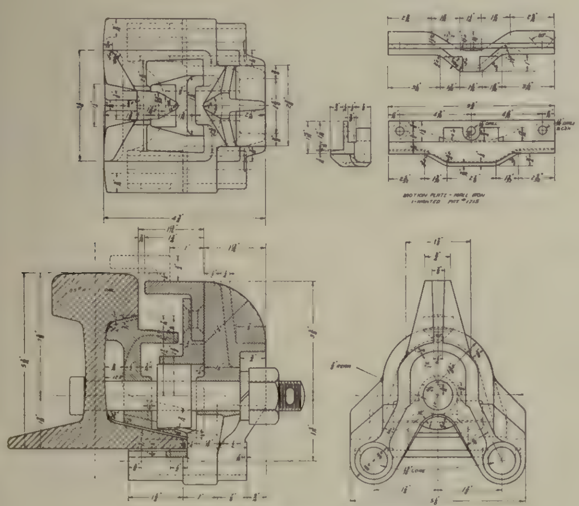
Figs. 1601-1603. Inside Parallel Bar. Great Western Railway of England.

occupied. The detector bars may be driven from cranks (Figs. 1479-1482 and 1484-1485) or from rocker shaft suspended below the rails. (Fig. 1483.)

Fig. 1562 shows a device for operating one detector bar in connection with two switch and lock movements. At each end of the rocker shaft are arms connected to links, the upper ends of which travel in guides A and B, and are driven by the switch and lock movements. The action of the device can clearly be seen by reference to the small diagrams. The bar in this case moves from its normal position to the center of the stroke and back, never going to the full reverse position.

FEDERAL SWITCH GUARD.

The Federal switch guard consists of an angle iron held in proper relation to the rail by specially designed guides. The upper or horizontal leg of the angle has its edge in contact with the head of the rail and slightly below the top of it.



Figs. 1604-1607. Federal Switch Guard.

Before the switch to which the guard is attached can be operated or even unlocked, the angle iron must be raised above the top of the rail and then moved inward, the vertical motion being three-quarters of an inch and the horizontal one inch. This movement insures the proper protection even under conditions which would cause the ordinary detector bar to fail. The use of special rail braces used with detector bars is unnecessary, as there is ample room between vertical leg of angle and head of rail for any rail brace.

THE UNION SPIRAL SWITCH GUARD.

The general construction of this guard shown in Figs. 1608, 1609, and 1610 is the same as the motion plate detector bar

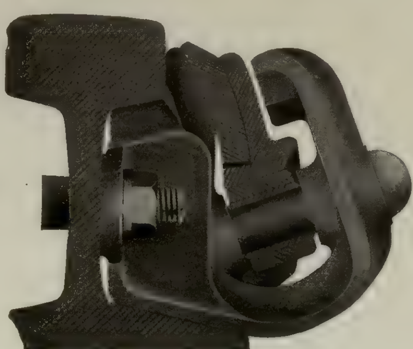
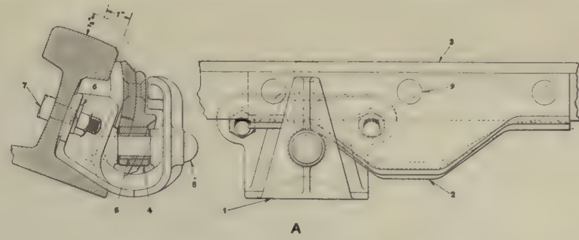


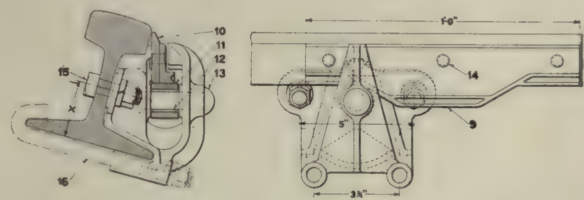
Fig. 1608. Spiral Switch Guard. Union Switch & Signal Company.

in general use, but its motion in operation is that of a spiral instead of an inclined plane. The form of the motion plate is such that the bar is caused to advance along the side of the rail and at the same time and by the same movement pass upward and over the top of the rail.

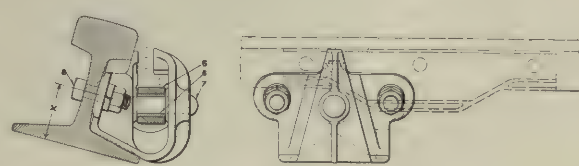


Figs. 1609-1610. Spiral Switch Guard.

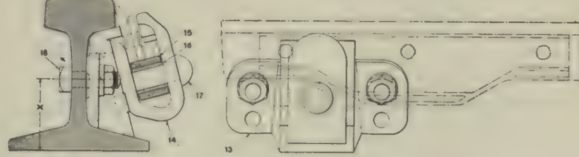
Fig. 1611. Combination Detector Bar Clip.



Figs. 1612-1613. Combination Detector Bar Rail Clip.



Figs. 1614-1615. Detector Bar Rail Clip Fastened with Web Bolts.



Figs. 1616-1617. Motion Plate Detector Bar Rail Clip. Wrought Iron Type. Union Switch and Signal Company.

If a car wheel is on the rail, at the time an attempt is made to move the bar, whose flange projects beyond the rail head, the motion of the bar will be arrested as soon as it comes in contact with the wheel tread. If, however, owing to excessive width of gauge from worn wheels and rails, the outer face of the wheel does not project beyond the rail, the spiral motion of the bar will bring it in contact with the face of the wheel and the further motion of the bar will be prevented.

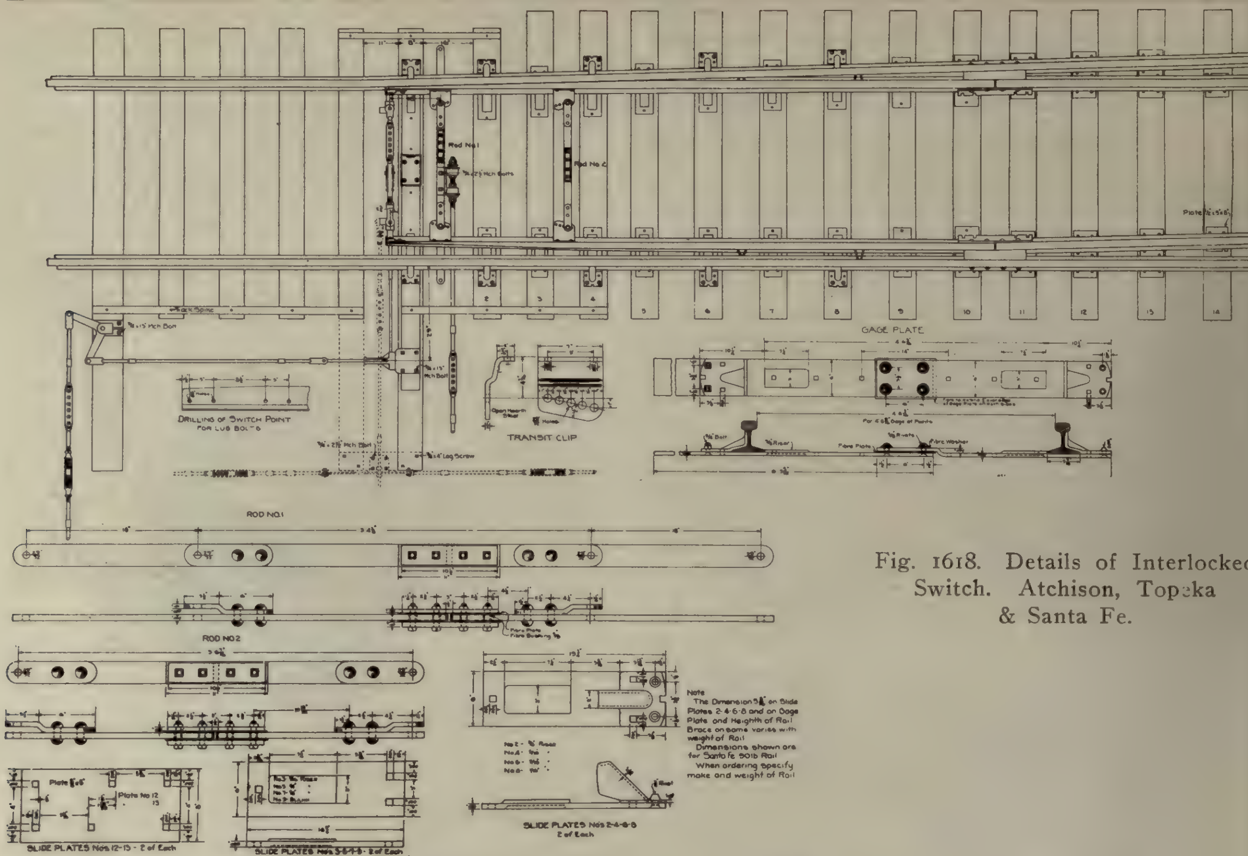


Fig. 1618. Details of Interlocked Switch. Atchison, Topeka & Santa Fe.

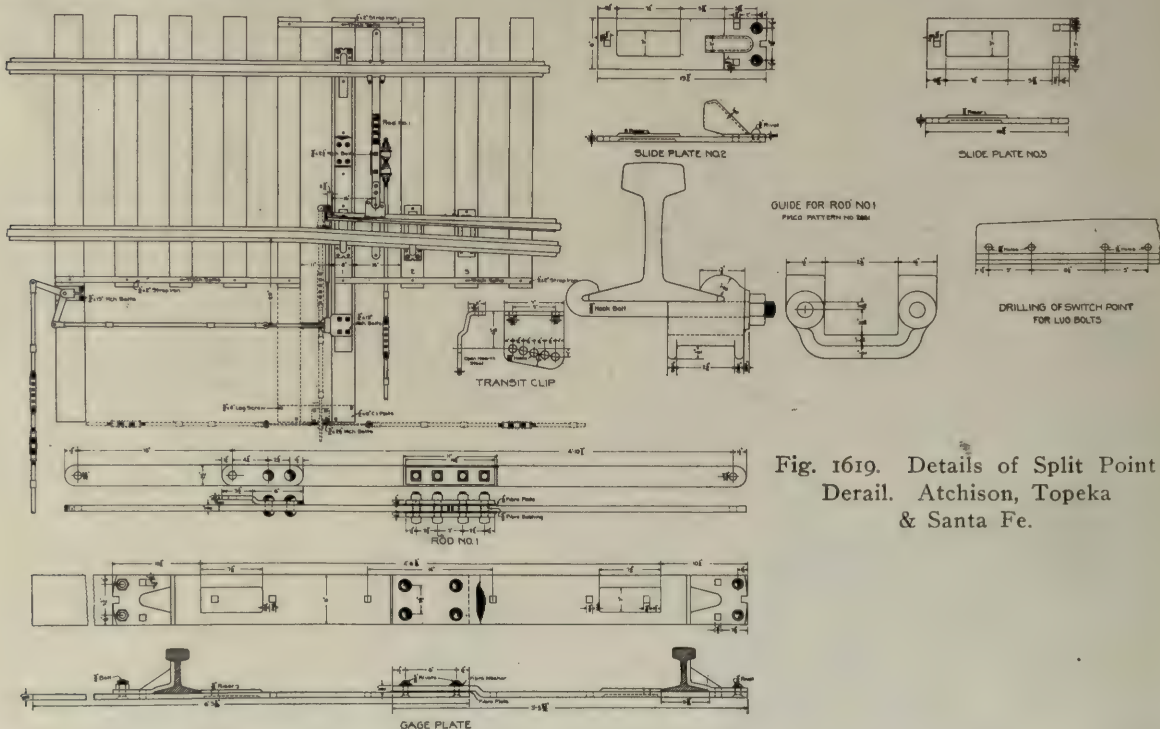


Fig. 1619. Details of Split Point Derail. Atchison, Topeka & Santa Fe.

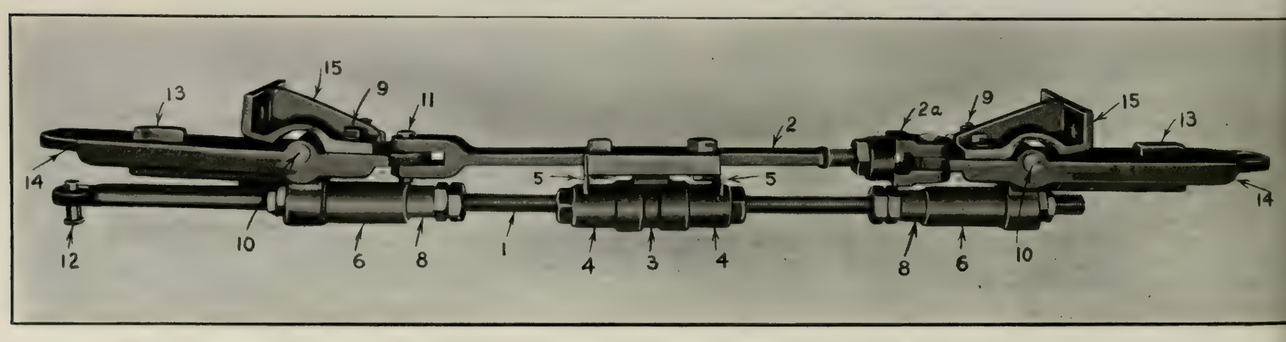


Fig. 1620. Nickerson Single Lever Safety Switch Lock. W. F. Bossert Manufacturing Company

DERAILS.

When it is desired to be sure that a train will not run past a stop signal (as in the case of grade crossings, drawbridges, etc.), it is customary to provide means of derailing the train if it should do so, by using some form of derailing switch. This often consists of one-half of an ordinary split point switch; that is, the half that is closed for main track movements, the other side of the track being a continuous rail. Other ways of accomplishing the same result, involve a rail

Fig. 1621. Freeland Mechanical Throw Derailers No. 7.

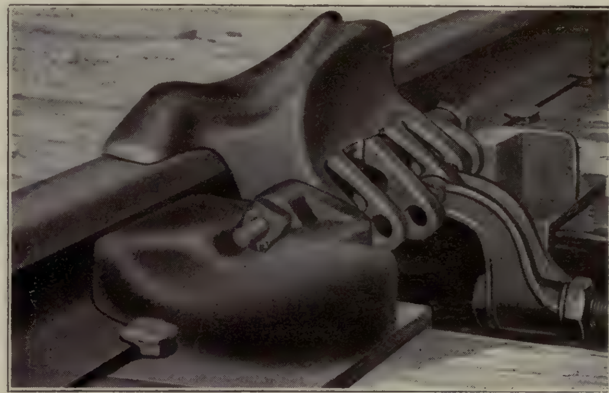


Fig. 1622. Freeland Mechanical Throw Derailers, No. 8.

Fig. 1623. Installation of Freeland Derailer on the Northern Pacific.

which is brought against the gauge line to deflect the wheel flange, the opposite flange being raised over the ball of the rail by an inclined rail which catches the overhang of the tread, and raises it so that the flange clears. Derails of this type are known as "unbroken rail derails."

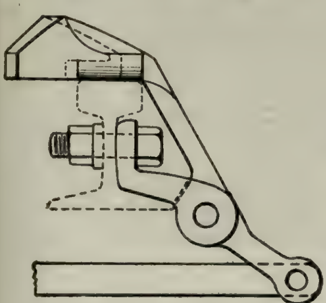


Fig. 1624. Lifting Derail. Railroad Supply Company.

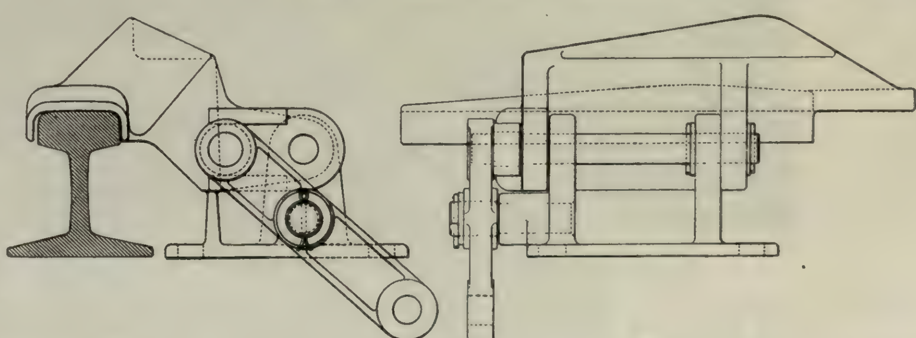


Fig. 1625. Anderson-Bevan Derail. General Signal Company.

The Anderson-Bevan derail (Fig. 1625) made by the General Railway Signal Co. consists of a derailing block mounted in a stand designed to be fastened to a tie. The block is carried on an arm pivoted in the stand so that it can swing on and off of the rail. The block has a channel in the bottom which rests over the rail head and takes the lateral thrust. Connection is made to the operating apparatus through a centrally pivoted lever whose upper end carries a lug acting in a cam slot on the side of the block. This also takes care of any overstroke in the connections.

FREELAND CLAMP DERAILS.

The Freeland clamp derailers made by The Hobart-Allfree Co. are furnished with two special screw jaws with interlocking pins. All derails have a lip or flange which engages the head of the rail and relieves the supporting brackets of the side thrust imparted to the derailing block at the time of the derailment. When the Freeland derailers are in the open position and the track is clear the derailing block falls into pockets formed by the base. The derailer No. 7 is 2 ft. 8 in. long, weighs 165 lbs. and may be operated by switch stand or from the interlocking plant. The No. 8 derailer is 20 in. long and weighs 125 lbs. The Freeland clamp derailers are designed for mechanical throw, and the Smyth derailers for hand throw.

THE HAYES DERAIL.

The Hayes derail (Figs. 1626-1638) consists of two parts, the derail block and the guide box. Both parts are malleable castings. Figs. 1629-1636 show successive positions of the derail block while it is being moved from the open to the closed position. In the line drawings (Figs. 1630-32-34-36) the derail block is shown in heavy shading. This derail block carries four round pins, two on each side. These pins slide in the cam slots in the guide box and serve to guide the derail block up, over and down away from the rail. The lugs at the front end of the derail block next to the rail rest against seats in the guide box when the derail is open or on the rail. These seats hold the derail block from leaving the rail except by rising above it at the same time. The thrust at right angles to the rail of a wheel encountering the derail block is carried by these seats in the guide box to the ties and roadbed. The weight of a wheel passing over the block serves to hold the derail more firmly in place. Thrust parallel to the rail is carried by these same lugs on the derail block to the side walls of the guide box and thence to the ties. There are two lugs at the back end of the derail block with holes for attaching to operating and locking devices. Fig. 1628 is a view of the derail just described, in track. Fig. 1627 is a similar design, but has a reversible eyebolt between the two back lugs, affording three connections to the derail block, one for the operating rod, one for a facing point lock and the third for a wire bolt lock. Fig. 1638 shows a different model designed to be operated by hand only. It cannot be attached to an operating rod. The two castings are joined by a piece of cold-rolled steel shafting, riveted in place. Hayes derails are made in five styles, being models A, AP, C, CP and CX for operation by pipe line or switch stand. They are made in three styles, models D, E, and EX for hand operation. Hayes derails are made in three sizes: size 4 is for use on rail from three to four inches high; size 5 is for use on rail over four and up to five inches high; size 6 is for use on rail more than five inches high.

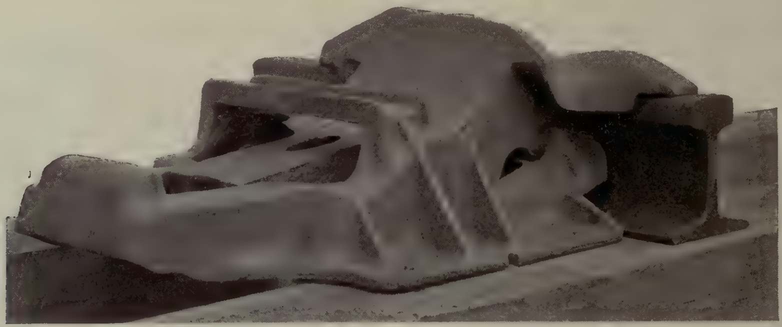


Fig. 1626. Hayes Derail, Model C. Open.

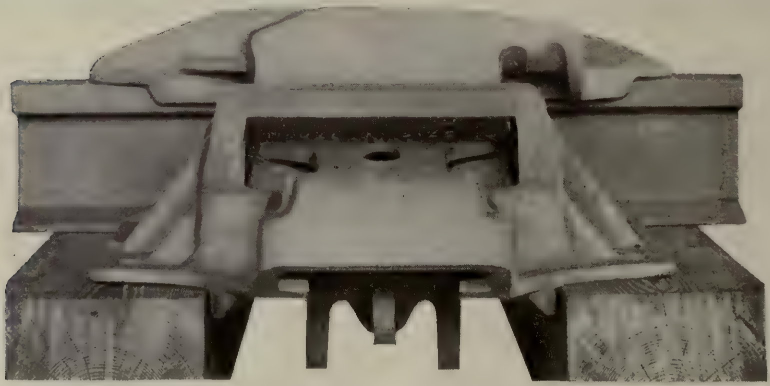
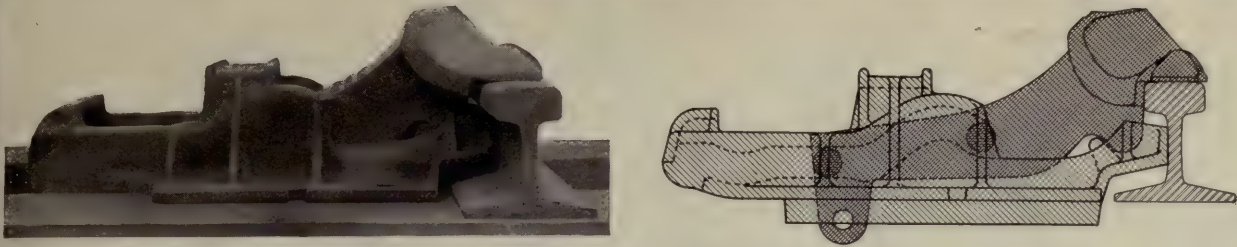
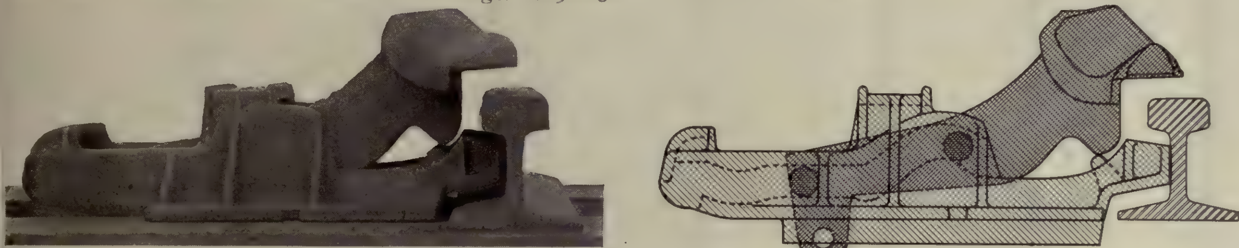


Fig. 1627. Hayes Derail. Model CP, with Extra Connection for Bolt Lock.

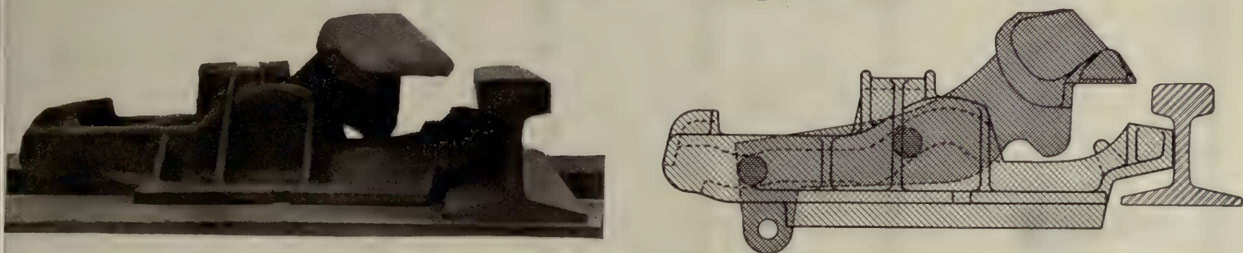
Fig. 1628. Hayes Derail, Model C, Operated by Motor.



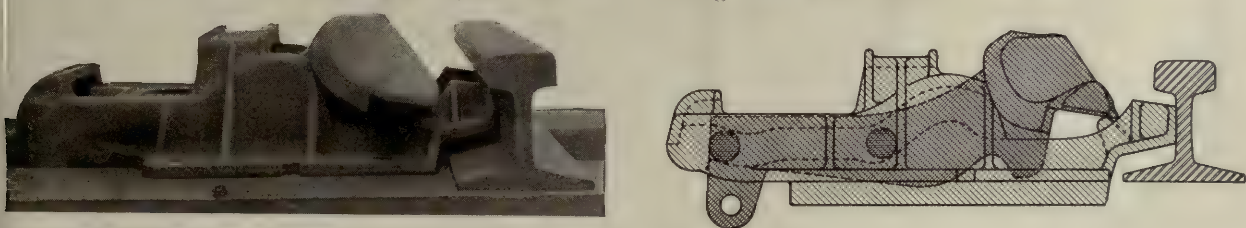
Figs. 1629-1630. Derail Open.



Figs. 1631-1632. Derail Block Leaving Front Seats.



Figs. 1633-1634. Derail Block Falling Past Head of Rail.



Figs. 1635-1636. Derail Closed.

Figs. 1629-1636. Hayes Derail in Successive Positions.

Fig. 1637. Hayes Derail, Model C, with Operating Stand.

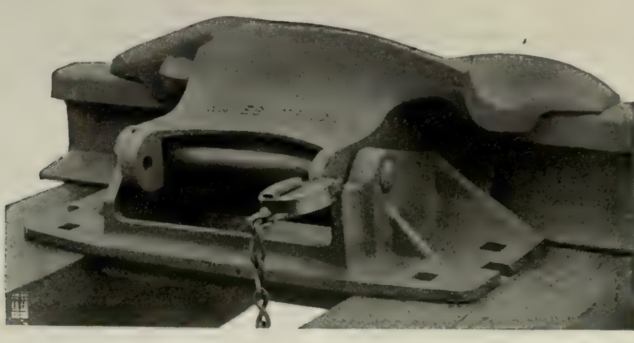
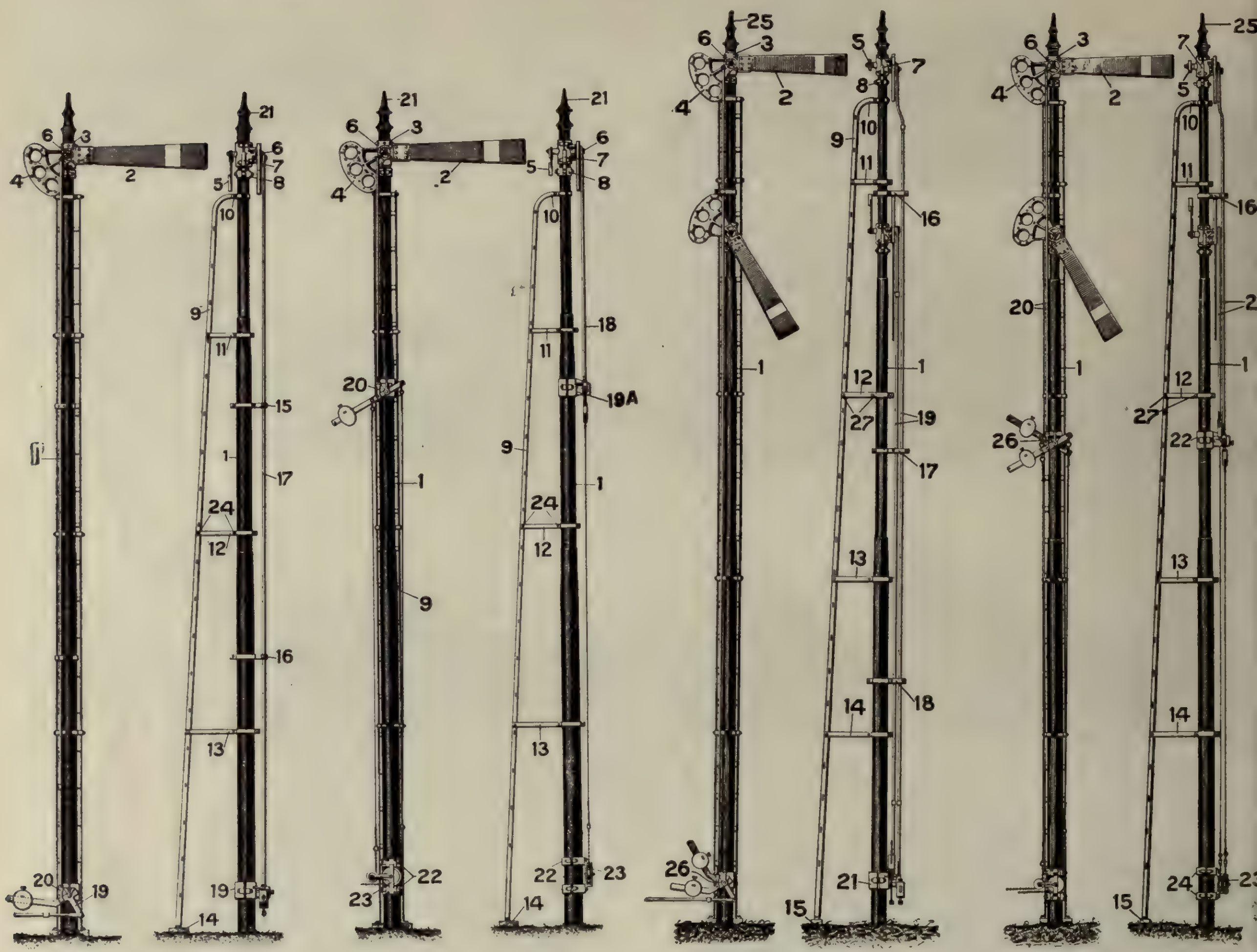


Fig. 1638. Hayes Derail, Model E, Hand Operated Type, Open.

SIGNALS.



Figs. 1639-1640. Pipe Connected. Figs. 1641-1642. Wire Connected.

One Arm.

Figs. 1643-1644. Pipe Connected. Figs. 1645-1646. Wire Connected.

Two Arm.

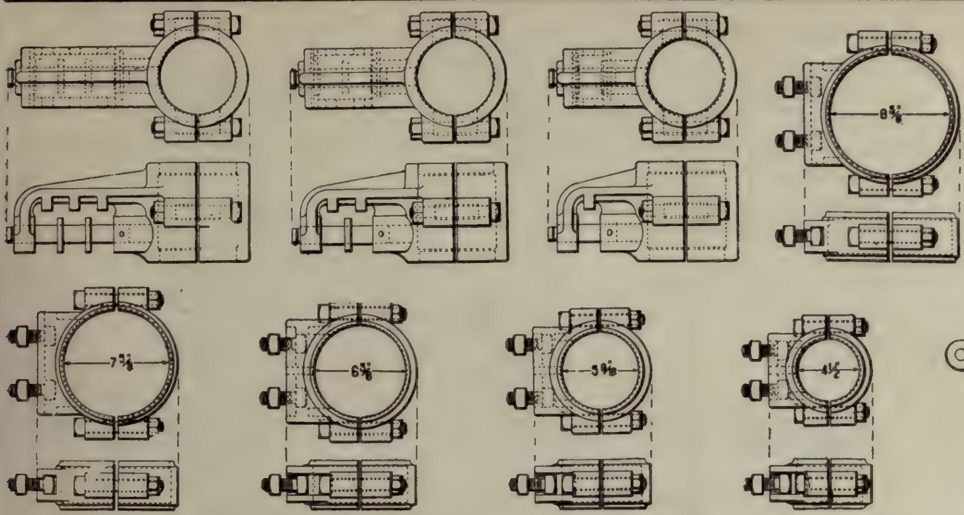
Figs. 1639-1646. Iron Post Mechanical Interlocking Signals.

Names of Parts, One Arm Iron Pipe Post Mechanical Interlocking Signal; Figs. 1639-1642.

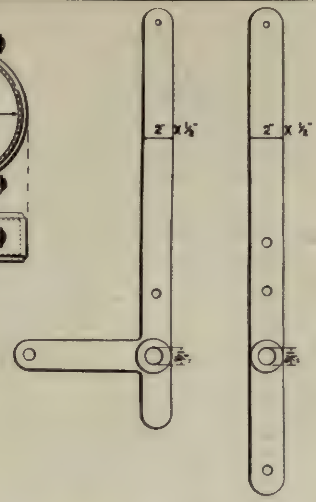
1 *Iron Pipe Post*
2 *Blade*
3 *Semaphore Bearing*
4 *Spectacle*
5 *Back Spectacle*
6 *Semaphore Shaft*
7 *Lamp Bracket*
8 *Lamp Bracket Clamp*
9 *Ladder*
10 *Ladder Clamp*
11 *Ladder Stay*
12 *Ladder Stay*
13 *Ladder Stay*
14 *Ladder Foundation*
15 *Pipe Guide*
16 *Pipe Guide*
17 *Up and Down Rod*
18 *Up and Down Rod*
19 *Balance Lever Stand with Clamp for Pipe Connected Signal*
19A *Balance Lever Stand with Clamp for Wire Connected Signal.*
20 *Screw Jaw*
21 *Pinnacle*
22 *Signal Wheel Clamp*
23 *Signal Wheel*
24 *Ladder Stay Bolt*

Names of Parts, Two Arm Iron Pipe Post Mechanical Interlocking Signal; Figs. 1643-1646.

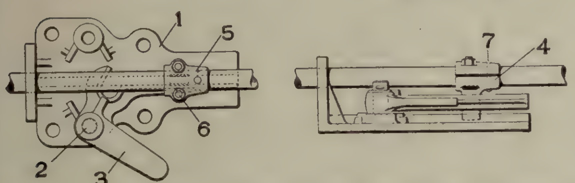
1 *Iron Pipe Post*
2 *Blade*
3 *Semaphore Bearing*
4 *Spectacle*
5 *Back Spectacle*
6 *Semaphore Shaft*
7 *Lamp Bracket*
8 *Lamp Bracket Clamp*
9 *Ladder*
10 *Ladder Clamp*
11 *Ladder Stay*
12 *Ladder Stay*
13 *Ladder Stay*
14 *Ladder Stay*
15 *Ladder Foundation*
16 *One Way Pipe Guide*
17 *Two Way Pipe Guide*
18 *Two Way Pipe Guide*
19 *Up and Down Rods for Pipe Connected Signal*
20 *Up and Down Rods for Wire Connected Signal*
21 *Two Way Balance Lever Stand with Clamp for Wire Connected Signal*
22 *Two Way Balance Lever Stand with Clamp for Wire Connected Signal*
23 *Two Way Signal Wheel*
24 *Signal Wheel Clamp*
25 *Pinnacle*
26 *Screw Jaw*
27 *Ladder Stay Bolt*



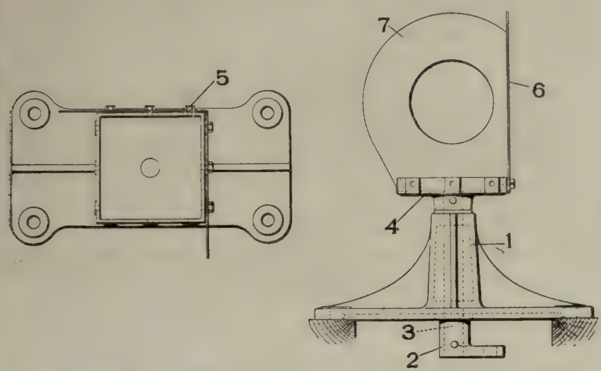
Figs. 1647-1661. Clamps and Clamp Crank Stands for Iron Pipe Posts.



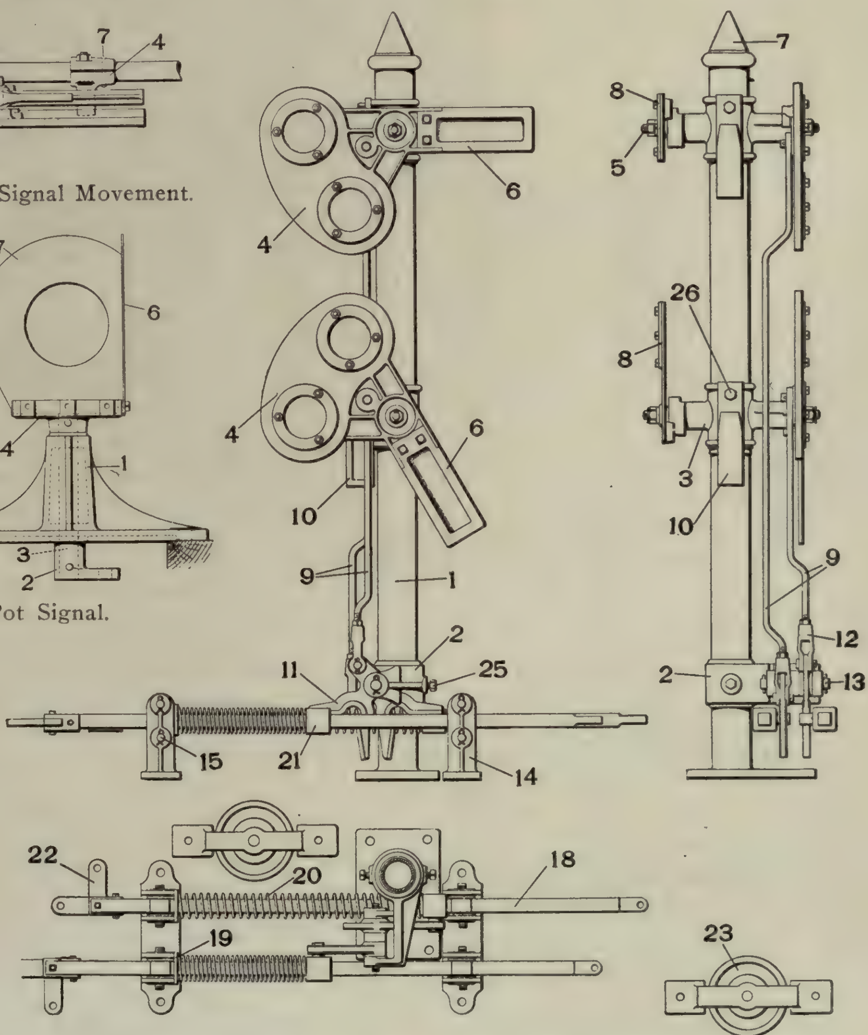
Figs. 1662-1663. Balance Levers.



Figs. 1664-1665. Special Dwarf Signal Movement.



Figs. 1666-1667. Low Pot Signal.



Figs. 1668-1671. Two-Arm Dwarf Signal, with Restoring Springs.

Names of Parts, Two-Arm Dwarf Signal with Restoring Springs; Figs. 1668-1671.

1 *Combination Base and Pole*
2 *Two Way Crank Stand*
3 *Lower Semaphore Bearing*
4 *Spectacle*
5 *Semaphore Shaft*
6 *Blade*
7 *Pinnacle*
8 *Back Spectacle*
9 *Up and Down Rod*
10 *Lamp Bracket*
11 *Escapement Crank*
12 *Screw Jaw*
13 *Pin*
14 *Two Way Guide Stand*
15 *Pin with Cotters*
18 *Operating Shaft with Eye*
19 *Spring Plate*
20 *Spring*
21 *Trunnion Block*
22 *Double Lug*
23 *6-in. Chain Wheel and Stand*
25 *Tap Bolt*
26 *Tap Bolt*

Names of Parts, Special Dwarf Signal Movement; Figs. 1664-1665.

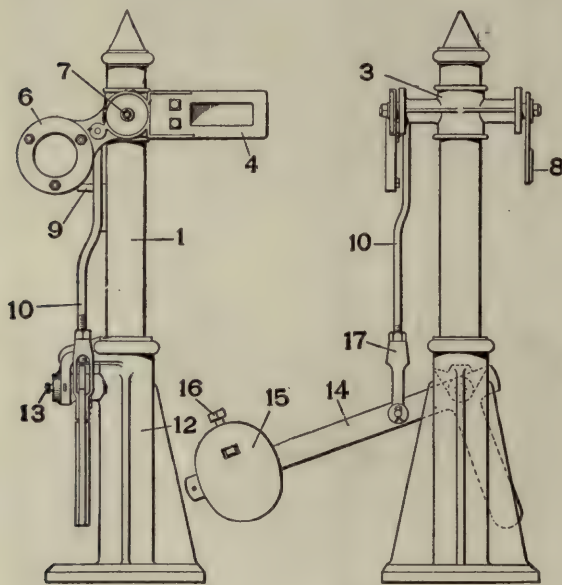
1 *Stand*
2 *Stud with Cotter*
3 *Escapement Crank*
4 *Trunnion*
5 *Trunnion Cap*
6 *Bolt*
7 *Rivet*

Names of Parts of Low Pot Signal; Figs. 1666-1667.

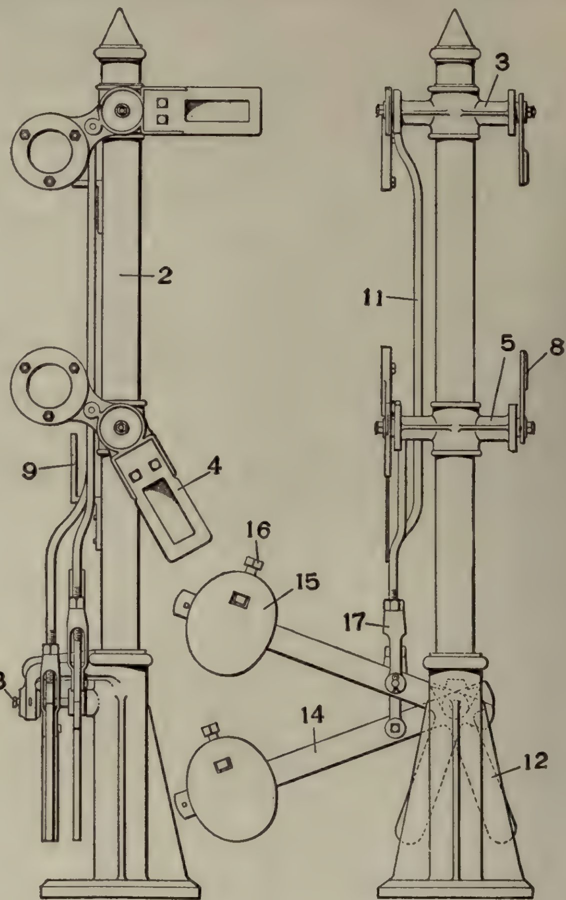
1 *Stand*
2 *Crank*
3 *Crank Shaft*
4 *Lamp Base*
5 *Tap Bolt*
6 *Stop Target*
7 *Clear Target*

Names of Parts, Dwarf Signals; Figs. 1672-1675.

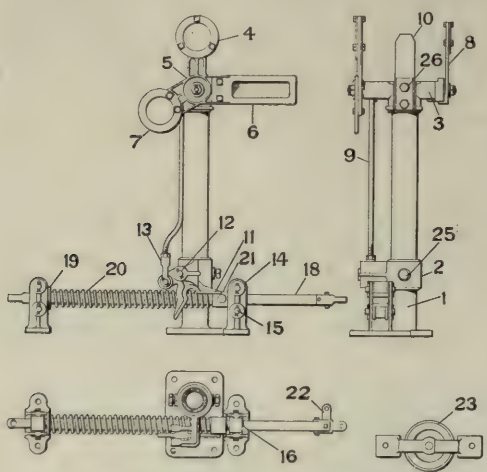
1 *Iron Pipe Post*
2 *Iron Pipe Post*
3 *Semaphore Bearing*
4 *Blade*
5 *Semaphore Bearing*
6 *Spectacle*
7 *Semaphore Shaft*
8 *Back Spectacle*
9 *Lamp Bracket*
10 *Up and Down Rod*
11 *Up and Down Rod*
12 *Base*
13 *Pin*
14 *Balance Lever*
15 *Counterweight*
16 *Counterweight Bolt*
17 *Screw Jaw*



Figs. 1672-1673. One-Arm Dwarf Signal.



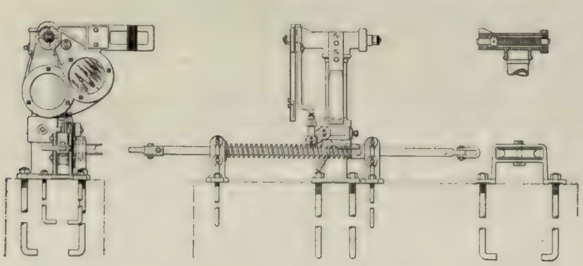
Figs. 1674-1675. Two-Arm Dwarf Signal.



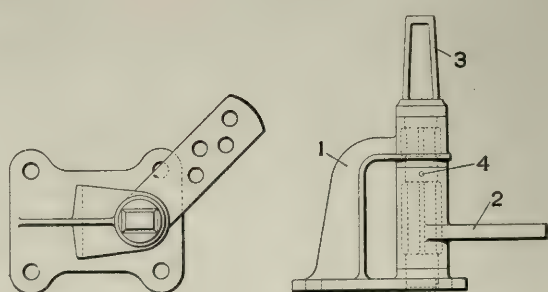
Figs. 1676-1679. One-Arm Dwarf Signal, with Spring Restoring Attachment.

Names of Parts, One-Arm Dwarf Signals with Spring Attachment; Figs. 1676-1679.

1 *Post and Base*
2 *Crank Bearing*
3 *Semaphore Bearing*
4 *Spectacle*
5 *Semaphore Shaft*
6 *Blade*
7 *Disc*
8 *Back Spectacle*
9 *Up and Down Rod*
10 *Lamp Bracket*
11 *Escapement Crank*
12 *Center Pin*
13 *Screw Jaw*
14 *Guide Stand*
15 *Pin and Cotter*
16 *Roller*
18 *Operating Shaft*
19 *Spring Plate*
20 *Spring*
21 *Trunnion Block*
22 *Double Lug*
23 *6-in. Wheel and Stand*
25 *Tap Bolt*
26 *Tap Bolt*



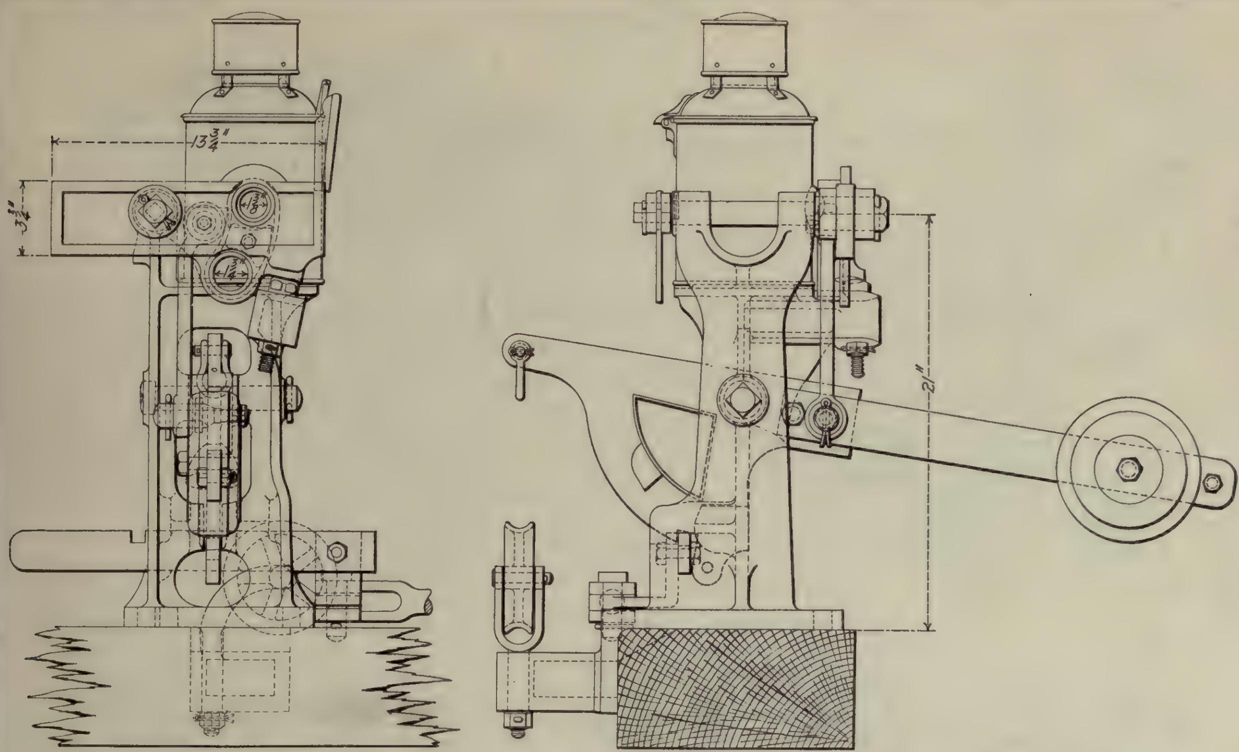
Figs. 1680-1681. 45 deg. Upper Quadrant Union Dwarf Signal Spring Attachment.



Figs. 1682-1683. Switch Light Stand.

Names of Parts, Switch Light Stand; Figs. 1682-1683.

1 *Stand*
2 *Crank Arm*
3 *Lamp Spindle*
4 *Dowel Pin*



Figs. 1684-1685. Single Dwarf Signal and Point Detector Combined. Great Western of England.

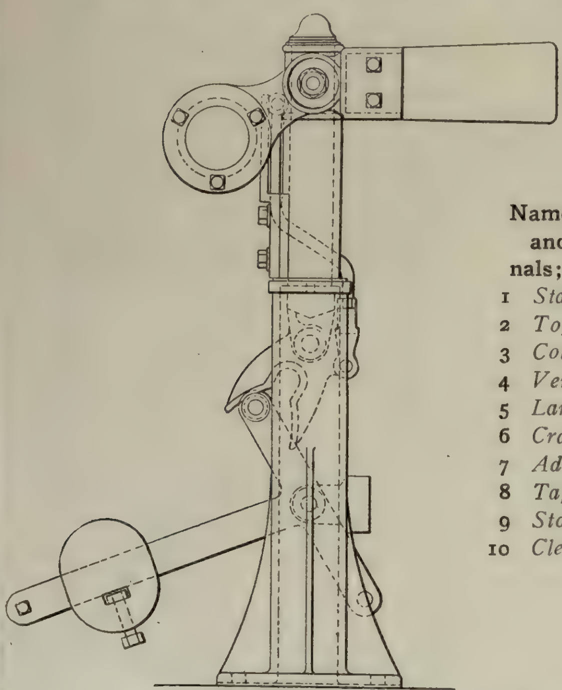
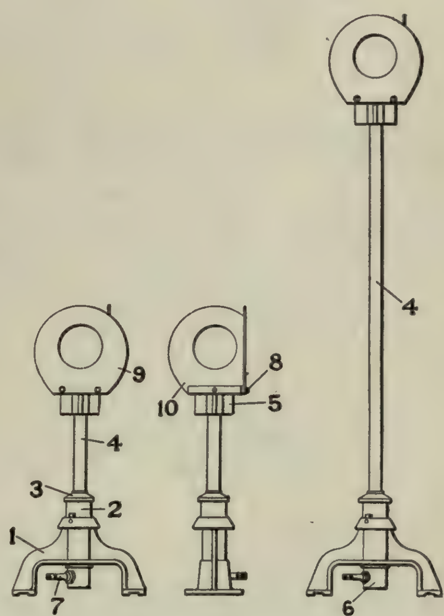


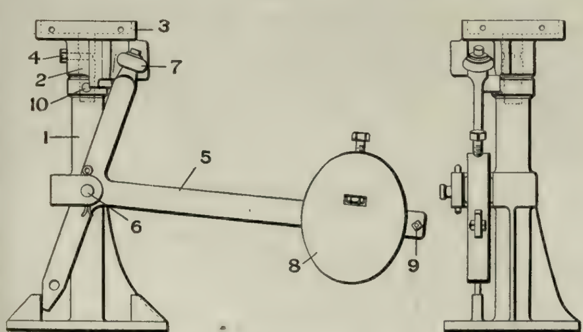
Fig. 1686. Compensating Dwarf Signal.

Names of Parts, High and Low Pot Signals; Figs. 1687-1689.

1 *Stand*
2 *Top Bearing Bushing*
3 *Collar*
4 *Vertical Shaft*
5 *Lamp Base*
6 *Crank Bushing*
7 *Adjustable Eye Bolt*
8 *Tap Bolt*
9 *Stop Target*
10 *Clear Target*



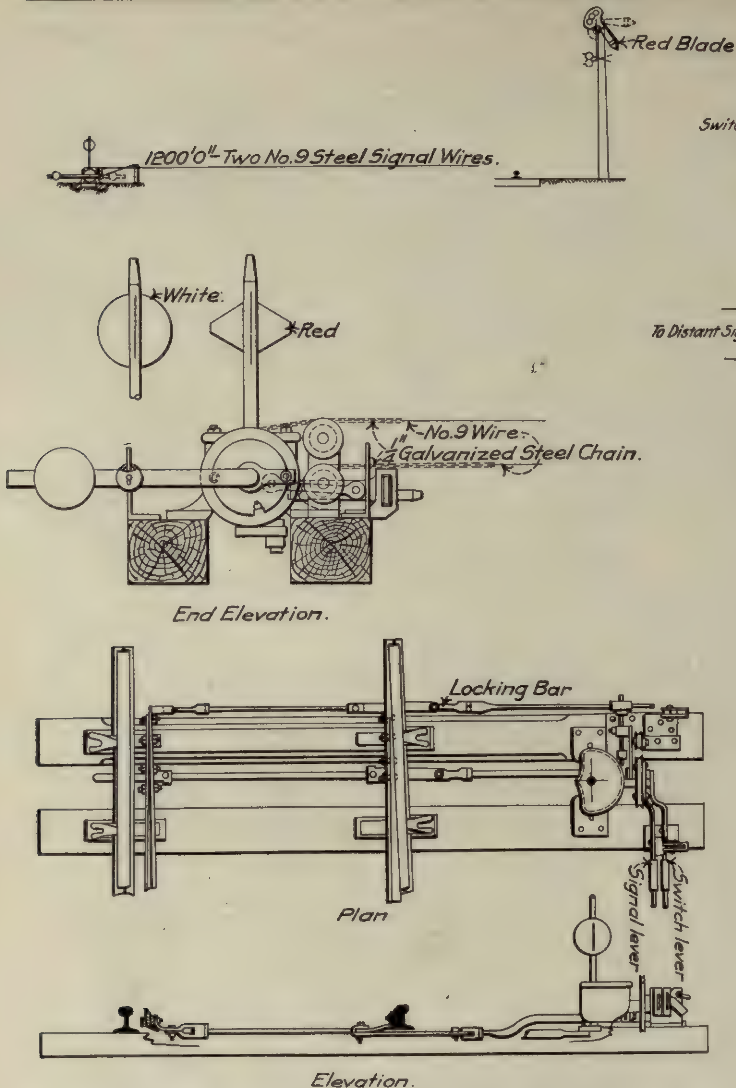
Figs. 1687-1689. Types of Pot Signals.



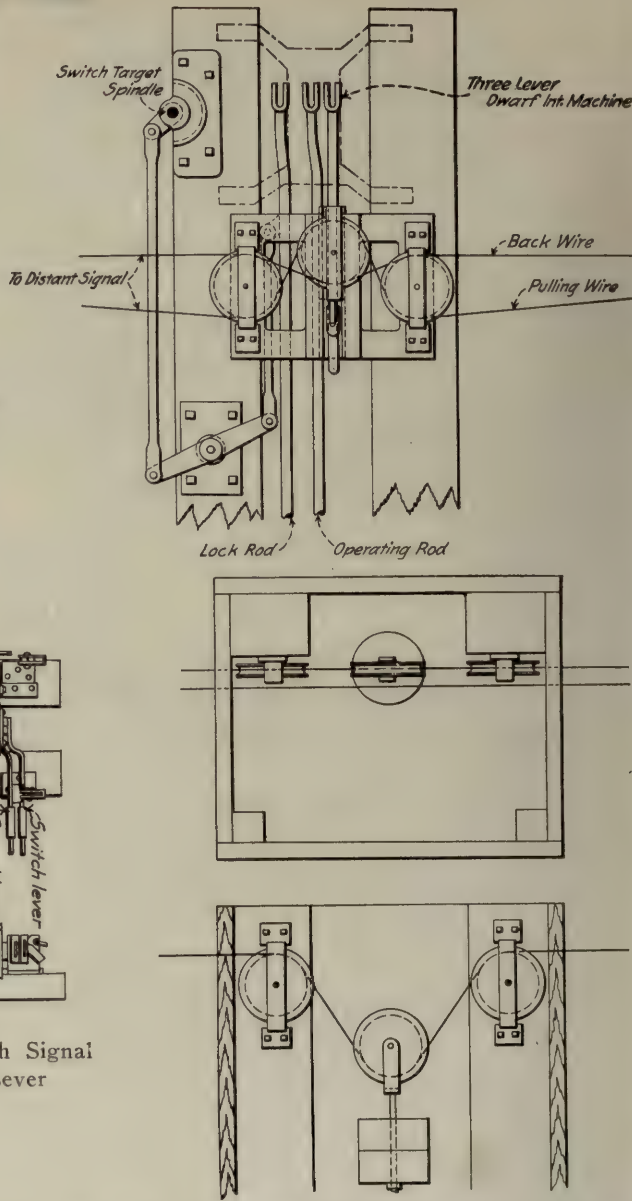
Figs. 1690-1691. Compensating Pot Signal, Johnson Type.

Names of Parts, Compensating Pot Signal, Johnson Type; Figs. 1690-1691.

1 *Stand*
2 *Stud*
3 *Lamp Base*
4 *Set Screw*
5 *Balance Lever*
6 *Pin*
7 *Roller*
8 *Counterweight*
9 *Stop Bolt*
10 *Dowel Pin*



Figs. 1692-1695. Layout and Detail of Distant Switch Signal and Facing Point Lock, Operated by Double Lever Switch Stand. New York Central.



Figs. 1696-1698. One Signal Operated from Two Switches; Details of Construction. Nashville, Chattanooga & St. Louis.

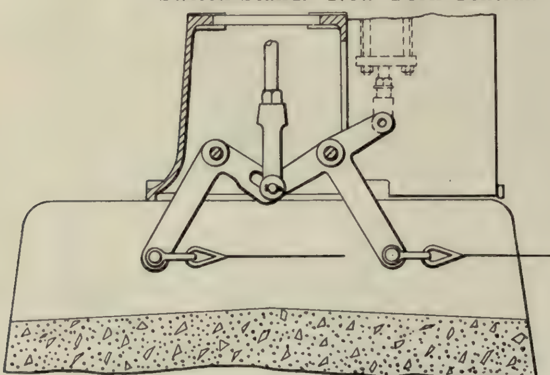


Fig. 1699. Electro-Pneumatic High Signal, Fitted to be Operated by Wire. Pennsylvania Railroad.

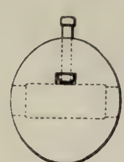


Fig. 1700. Counterweight.

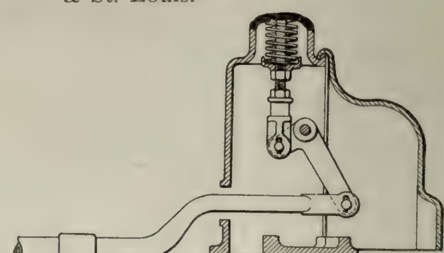


Fig. 1701. Electro-Pneumatic Dwarf Signal Fitted for Pipe Operation. Pennsylvania Railroad.

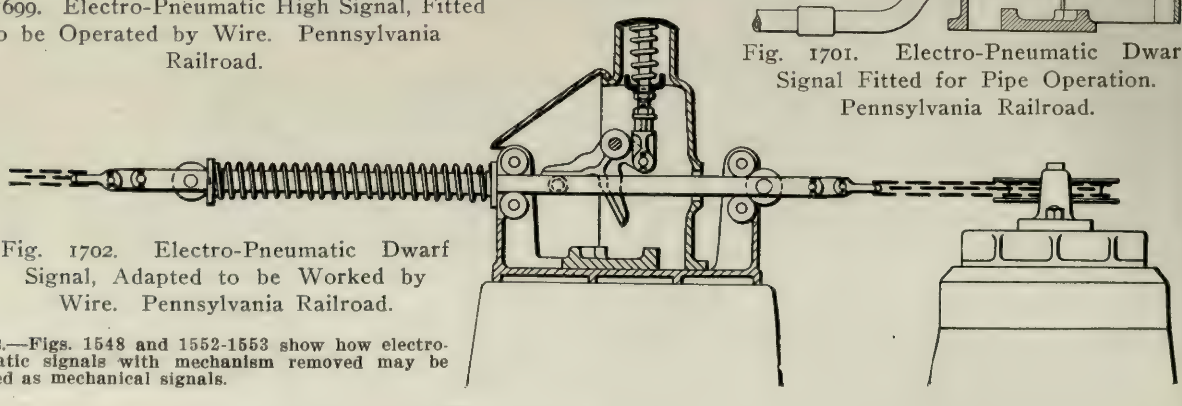
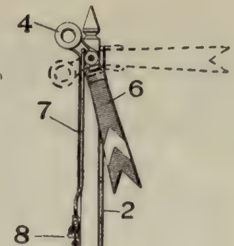


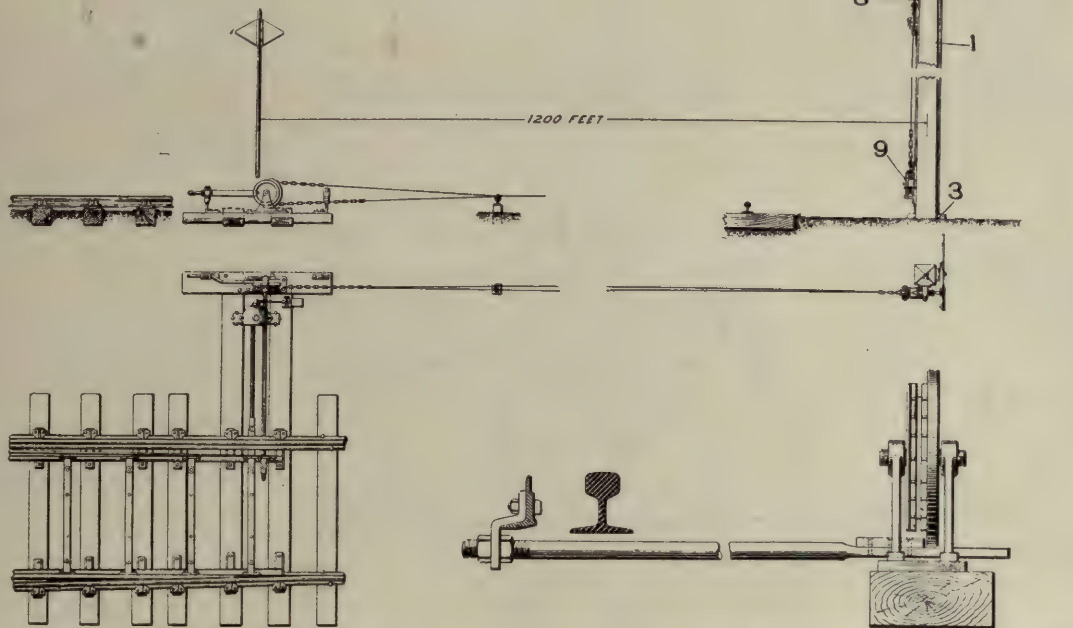
Fig. 1702. Electro-Pneumatic Dwarf Signal, Adapted to be Worked by Wire. Pennsylvania Railroad.

Note.—Figs. 1548 and 1552-1553 show how electro-pneumatic signals with mechanism removed may be operated as mechanical signals.

Names of Parts of Distant Switch Signal; Figs. 1703-1705.

1 *Wooden Post*
2 *Ladder*
3 *Ladder Foundation*
4 *Spectacle*
6 *Blade*
7 *Up and Down Rod*
8 *Balance Lever and Stand*
9 *Signal Wheel and Stand*





Figs. 1703-1705. Distant Switch Signal, Wire Connected and Operated by Ground Lever and Rim Lock. Union Switch & Signal Company.

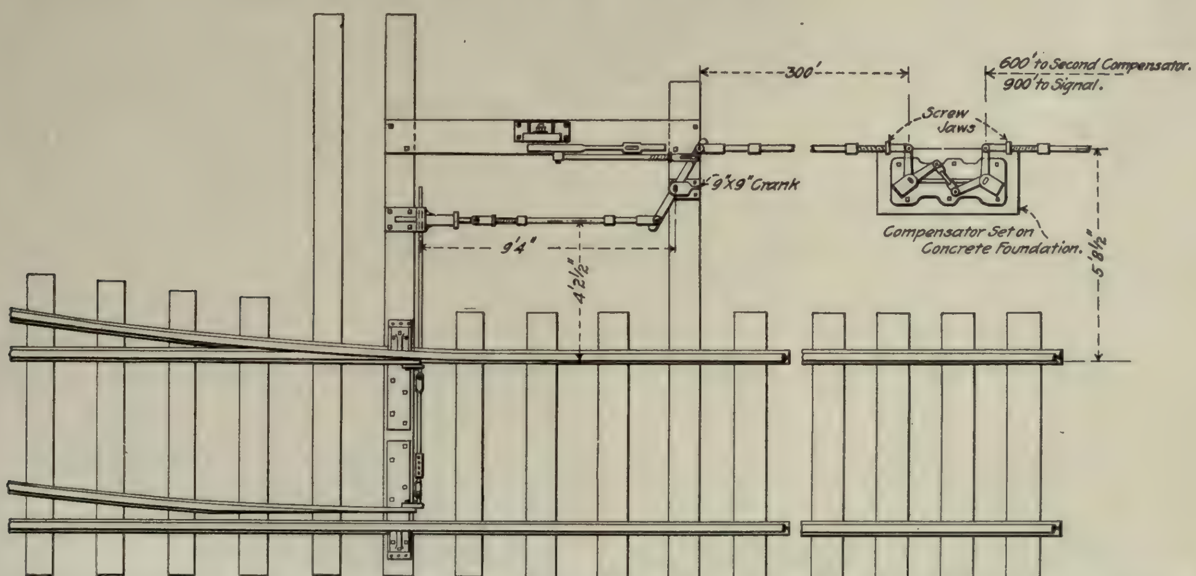
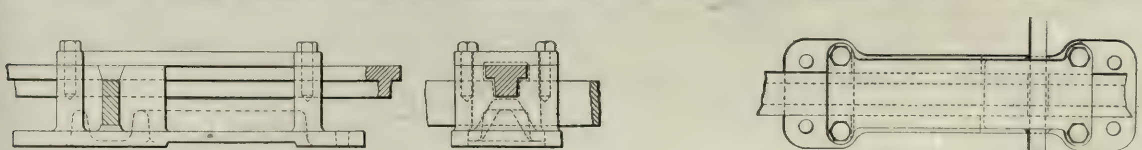


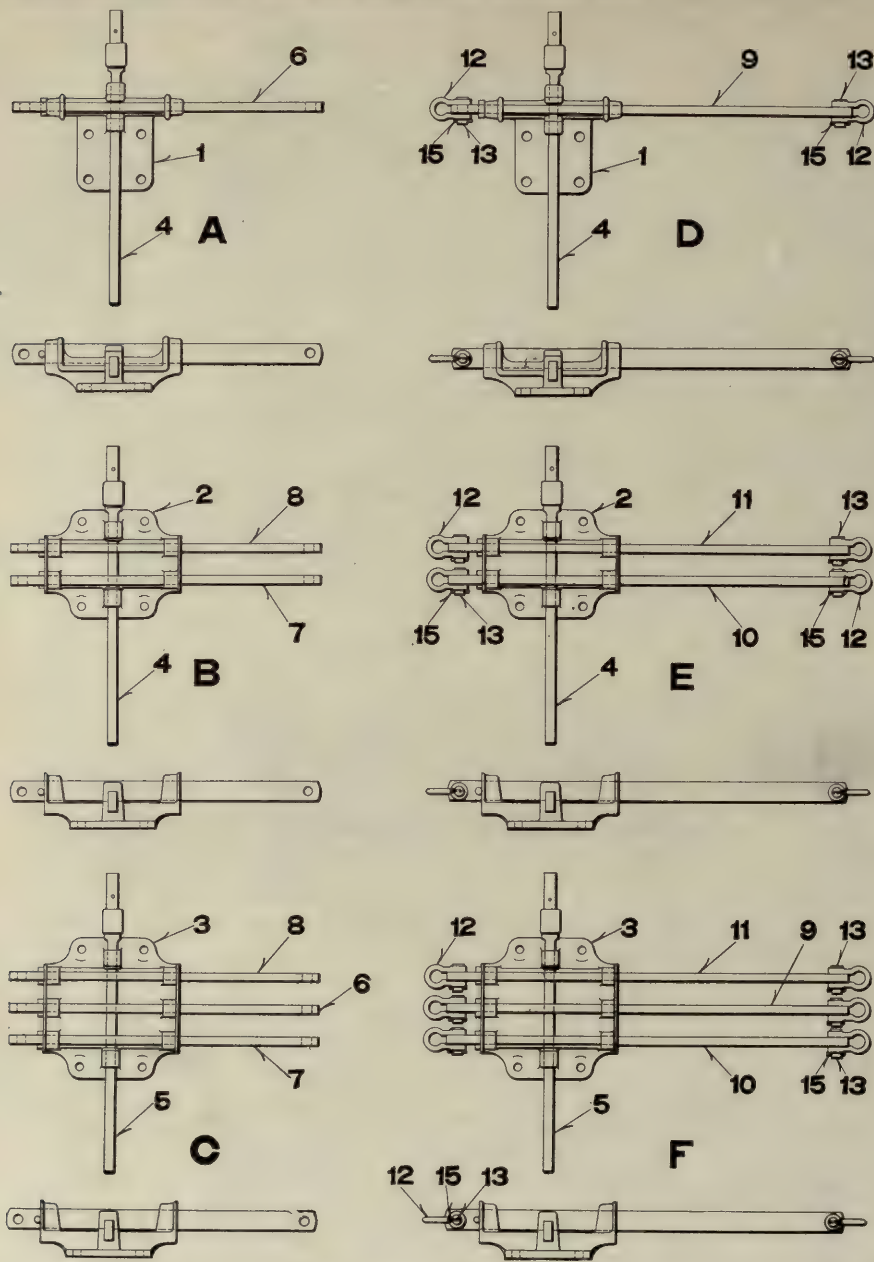
Fig. 1706. Layout for Pipe Connected Distant Switch Signal and Facing Point Lock. New York, Ontario & Western.

BOLT LOCKS.

It is customary to bolt lock all high speed signals with facing point switches in the route governed, so that should the switch be set wrong or be partially open, on account of broken switch or facing point lock connections, the signal could not be cleared. A bolt lock (Figs. 1710-1725) consists of two notched bars working at right angles to each other in a frame. One rod is connected to the switch point and the other forms part of the line to the signal. The notches are so arranged that unless the switch is set right the signal bar



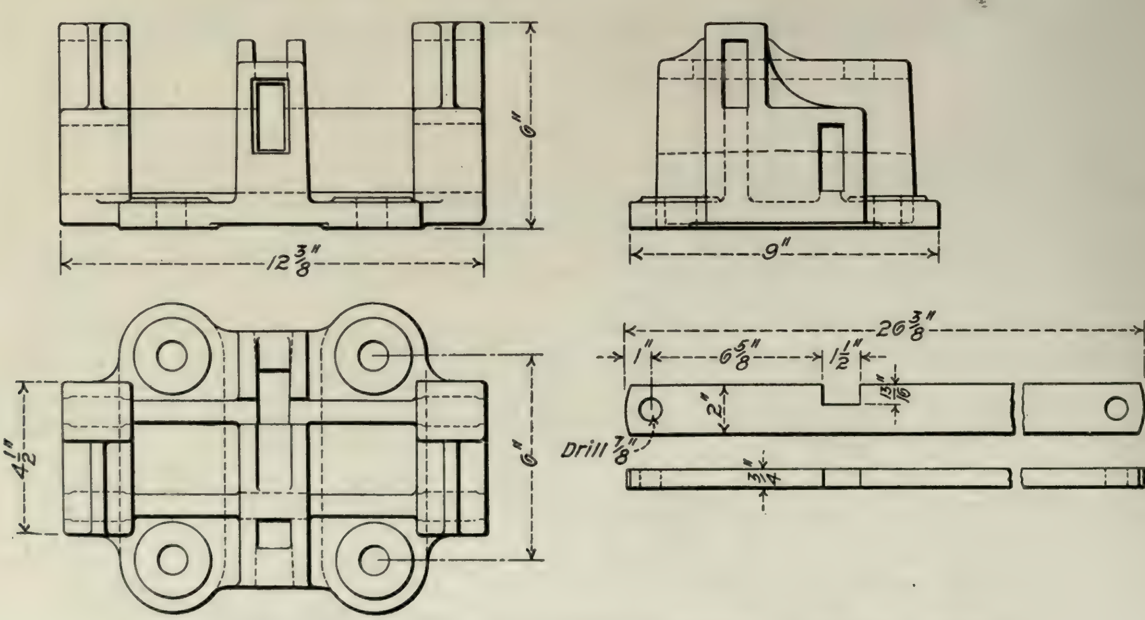
Figs. 1707-1709. Point Detector or Bolt Lock. Great Western Railway of England.



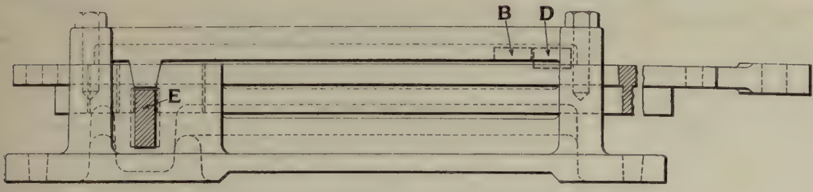
Figs. 1710-1721. Bolt Locks.

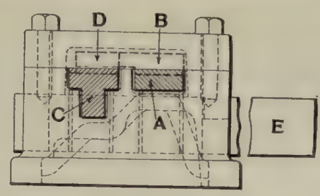
Names of Parts, Bolt Locks; Figs. 1710-1721.

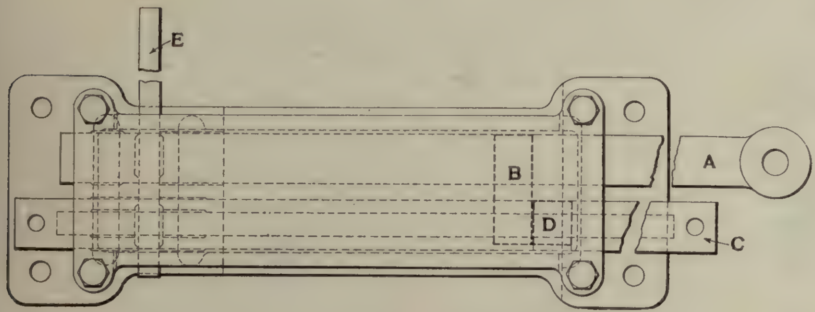
A *One-Way Bolt Lock, Pipe Connected*
B *Two-Way Bolt Lock, Pipe Connected*
C *Three-Way Bolt Lock, Pipe Connected*
D *One-Way Bolt Lock, Wire Connected*
E *Two-Way Bolt Lock, Wire Connected*
F *Three-Way Bolt Lock, Wire Connected*
1 *One-Way Stand*
2 *Two-Way Stand*
3 *Three-Way Stand*
4 *Switch-Bar for One or Two Way Stand*
5 *Switch-Bar for Three-Way Stand*
6 *Signal-Bar for Pipe Connection*
7 *Signal-Bar for Pipe Connection, Right-Hand Beveled*
8 *Signal-Bar for Pipe Connection, Left-Hand Beveled*
9 *Signal-Bar for Wire Connection*
10 *Signal-Bar for Wire Connection, Right-Hand Beveled*
11 *Signal-Bar for Wire Connection, Left-Hand Beveled*
12 *Shackle*
13 *Pin*
15 *Cotter*



Figs. 1722-1725. Two-Way Bolt Lock Details. Michigan Central.



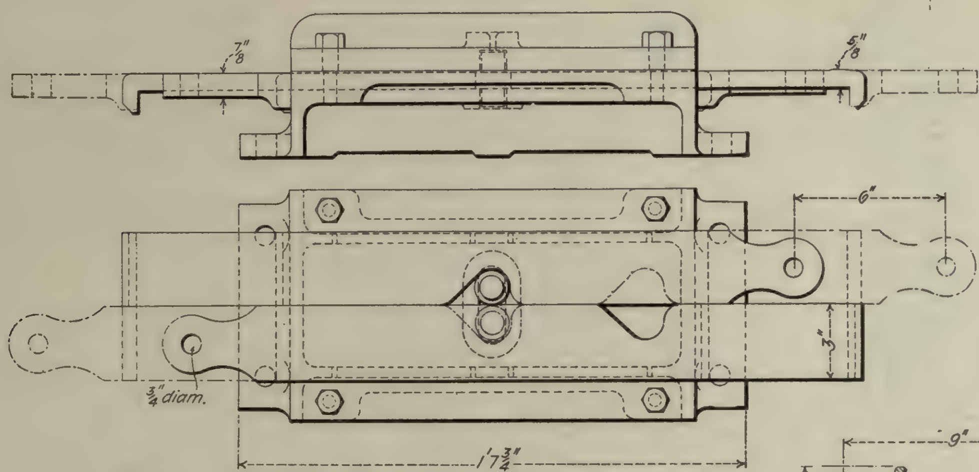




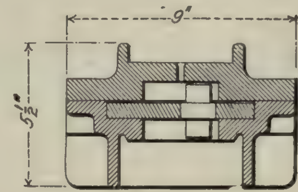
Figs. 1726-1728. Point Detector and Restorer. Great Western Railway of England.

Names of Parts, Point Detector and Restorer; Figs. 1726-1728.

A *Facing Point Lock Bar*
B *Block in* **A**
C *Signal Bar*
D *Block in* **C**
E *Switch Bar*



Figs. 1729-1731. Ground Lock. Great Western of England.



cannot move, and after the signal has been cleared its bar locks the switch bar so that the switch cannot be moved until the signal has been restored to the normal position.

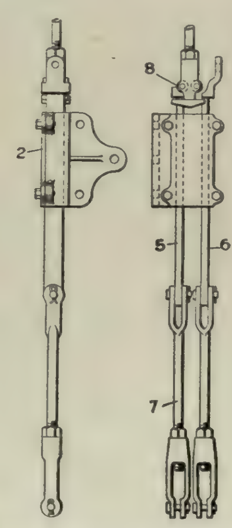
An English device, known as a "point detector and restorer," is shown in Figs. 1726-1728. It is essentially a bolt lock for use with wire connected signals when only one wire is used. E is the bar attached to the switch point, having a notch and interlocking with notched bar C as in American practice. C is connected in the signal line. Bar A is operated by the pipe line for the facing point lock. Block D is set into a notch in bar C, and block B into a notch in bar A. When the switch is locked bar A is pushed in, carrying block B with it. The signal can then be cleared. If, when the signal lever is put normal, the bar C should not make sufficient stroke to release E, the block B would strike against block D when the switch was unlocked, thus forcing C through the remainder of its stroke and releasing E. This device therefore automatically overcomes the effects of contraction between the lever and the bolt lock, and of slack wire between the bolt lock and the signal.

SLOTS.

Where it is desired to control one signal from two interlocking machines mechanically, a slot such as is shown in Figs. 1734-1735, may be used. This consists of a slide 2 moving in guides on casting 1, the latter being fastened to the signal post. Two vertical rods, one operated from each interlocking machine, move in 2. The connection to the semaphore casting is attached to the top of 2. The vertical rods strike against roller 8 when raised. If only one rod is raised the roller will move to one side out of its path; but if both are raised together, or one is raised while the other is already up, the roller will strike against the lug above it and the whole slide 2 will move upward and clear the signal. Stops 5 engage the bottom of slide 2 and assure its return to normal position when either rod is lowered. Lug 4 is used when the slot is applied to a double arm home and distant signal, when the home is controlled from one point and the distant from another. The home signal is actuated by a rod attached to 4 and the distant signal by a rod attached to the top of 2. Thus the distant arm cannot be cleared while the home arm is in the stop position. Another style of mechanical slot is shown in Figs. 1732-1733. The case 1 is fastened to the signal pole. Rods 5 and 6 move through the case which acts as a guide.

Names of Parts, Johnson Type Mechanical Slot; Figs. 1732-1733.

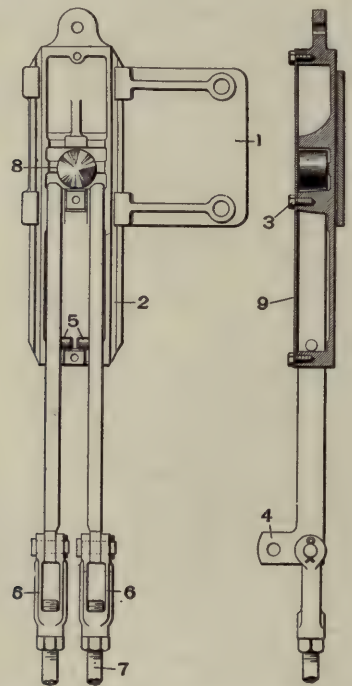
2 *Slot Case and Cover*
5 *Left Hand Vertical Slide*
6 *Right Hand Vertical Slide*
7 *Coupling Rod*
8 *Roller*



Figs. 1732-1733. Mechanical Slot. Johnson Type.

Names of Parts, Mechanical Slot; Figs. 1734-1735.

1 *Slot Guide*
2 *Slide*
3 *Tap Bolt*
4 *Right Hand Vertical Slide*
5 *Rivet Stop*
6 *Screw Jaw*
7 *Connecting Rod*
8 *Roller*
9 *Cover*



Figs. 1734-1735. Mechanical Slot.

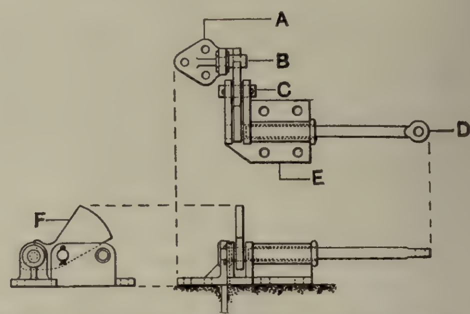
The signal up and down rod is attached to the swing jaw, which is equipped with two rollers 8 and a trangular lug. Dogs at top of rods 5 and 6 strike against the rollers when raised. Raising of one rod only pushes 8 over to the other side and does not affect the signal. Raising of both rods together or separately raises the up and down rod and clears the signal. Dogs on the ends of rods 5 and 6 engage with the triangular lug to insure that the signal will be restored to the stop position when either rod is lowered. The upper end of rod 6 is equipped with a lug to which the home signal is attached when home and distant are on same pole, as explained in connection with Figs. 1734-1735.

DRAWBRIDGE INTERLOCKING.

Drawbridge protection by interlocking involves some special devices. Couplers must be provided to make the pipe line continuous from shore to bridge. These consist of hooks and sockets mounted in frames (Figs. 1742-1744). One frame contains a hinged member for raising the sockets from engagement with the hooks. A separate lever may be used to disengage the line, or the same lever that unlocks the bridge may be employed. It is not customary to carry wire on the bridge deck. Where wire is used the line is changed to pipe on the bridge (Figs. 1745-1746). Usually clearances on bridges will not permit the use of horizontal compensators, so vertical compensators are employed. Safety demands that the bridge be locked in alignment and the rails in place before the signals can be cleared.

Figs. 1736-1738 illustrate a tumbler drawbridge lock for lift bridges. Casting A is carried on the bridge and to it is fastened a stud B fitting in a notch of the locking tumbler F. This tumbler is pivoted on plunger casting F. The stud B raises F when the bridge is closed. When the bridge opens the locking tumbler drops into the slot in front of the plunger, thereby preventing its passage all the way through E. This device acts as a check on the rail lock or the releasing lever, as it is necessary for the plunger to pass through E before either of the above can act.

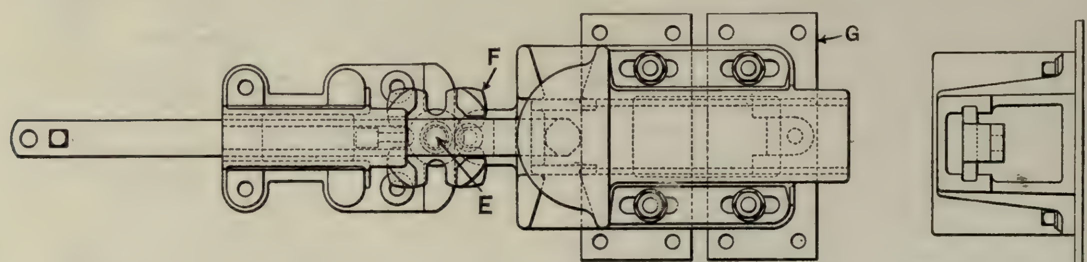
Figs. 1747-1749 illustrate a device for the same purpose as Figs. 1736-1738 applied to a swing bridge. Casting B is fastened to the bridge and casting C to the shore. Escapement



Figs. 1736-1738. Tumbler Bridge Lock.

Names of Parts of Tumbler Bridge Lock; Figs. 1736-1738.

A *Releasing Stand*
B *Stud*
C *Pin*
D *Plunger*
E *Plunger Casting*
F *Locking Tumbler*



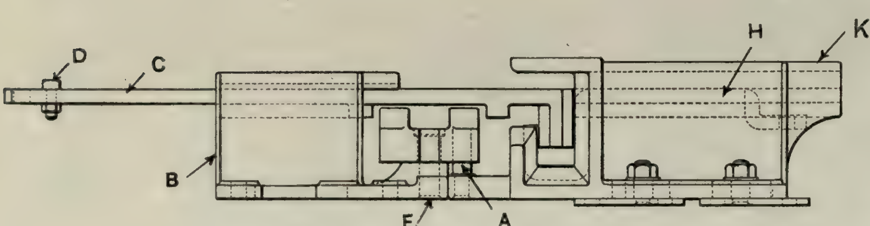


Fig. 1739-1741. Automatic Bridge Coupler.

Names of Parts, Automatic Bridge Coupler; Figs. 1739-1741.

A *Stud*
B *Abutment Casting and Guide*
C *Hook Bar*
D *Stop Bolt*
E *Stud*
F *Spider*
G *Base Plate*
H *Engaging Slide*
K *Coupler Casting*

lock F is pivoted to C and is engaged by a stud D on B to move it so that the notch comes opposite to the plunger opening when the bridge is closed. When the bridge opens F is moved in front of the plunger and blocks it. Figs. 1755-1757 show a similar device. The plunger here is very heavy and is designed to lock the bridge against movement if desired. The locking block D is moved to one side by a stud on casting E. Figs. 1753-1754 show a device designed for locking swing bridges. Here the tappet K works with the apparatus on the dogs 1 (Figs. 1750 and 1752) normally occupy the position A (Fig. 1751). When unlocked the dogs allow themselves to be raised by the lifting of the rail to the position B, locking the lug 2 and rocker shaft 3 in the reverse position. When the rail is again lowered it restores the dogs to their normal position, allowing 2 and 3 to revolve and securely lock the rail in place. An automatic bridge coupler for swing bridges is shown in Figs. 1739-1741. Casting K is mounted on the bridge and casting B on the abutment. K is provided with slotted bolt

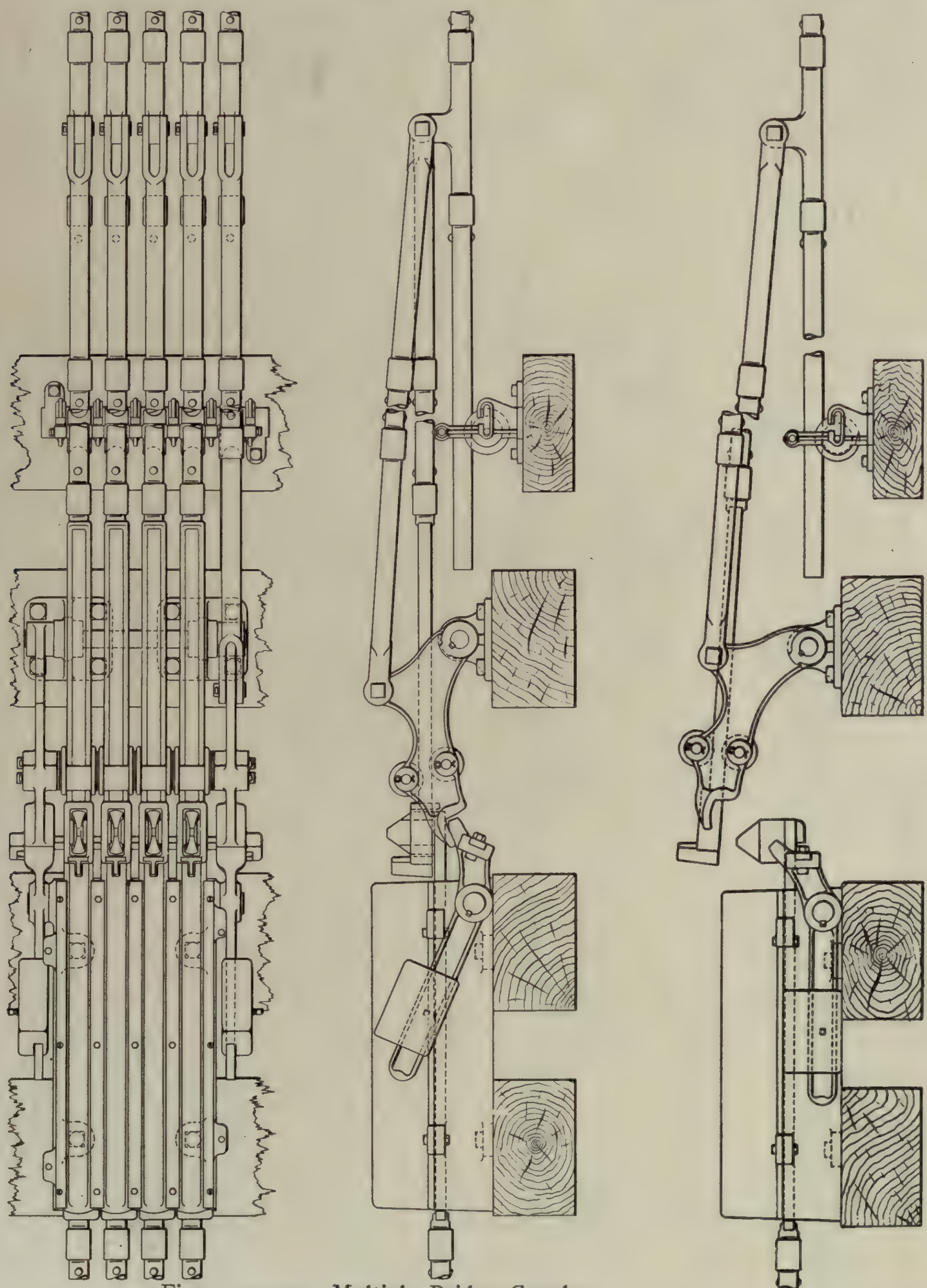


Fig. 1742-1744. Multiple Bridge Coupler.

bridge, while the plunger C is operated from the shore and holds the tappet against withdrawal. The tappet is guided by a box and rests on spring P, which absorbs shocks. It carries at its extremity a pin A which engages escapement jaw M, this jaw being pivoted in the plunger box B. When the tappet is withdrawn the stud pulls the escapement jaw in front of the plunger hole, where it remains blocking the plunger until the tappet is again inserted. Figs. 1758-1761 show bridge rail locks. They are used to lock the bridge rails in place. They consist of a modification of an inside connected facing point lock. The plunger casting has an opening through which a tongue fastened to the front rod passes. This tongue blocks the plunger when the rails are raised.

Figs. 1750-1752 show another type of rail lock. The rail holes for adjustment. On B is mounted a spider F, which revolves on a stud E through its center. It is provided with four dogs on its upper surface and has four notches in its circumference between the dogs. The pin A on K engages in one of the notches and holds the spider in position shown when the bridge is closed. When the bridge is opened the pin moves the spider through an angle of 45 degrees. In this position two of the dogs on the spider engage the two dogs on the lower surface of hook bar C which forms the shore end of the pipe line. Engaging slide H forms the bridge end of the pipe line; its end is bent as shown and engages the end of the hook bar. This makes the pipe line continuous from shore to bridge. Figs. 1745-1746 and 1758-1761 show applications of some of the apparatus just described.

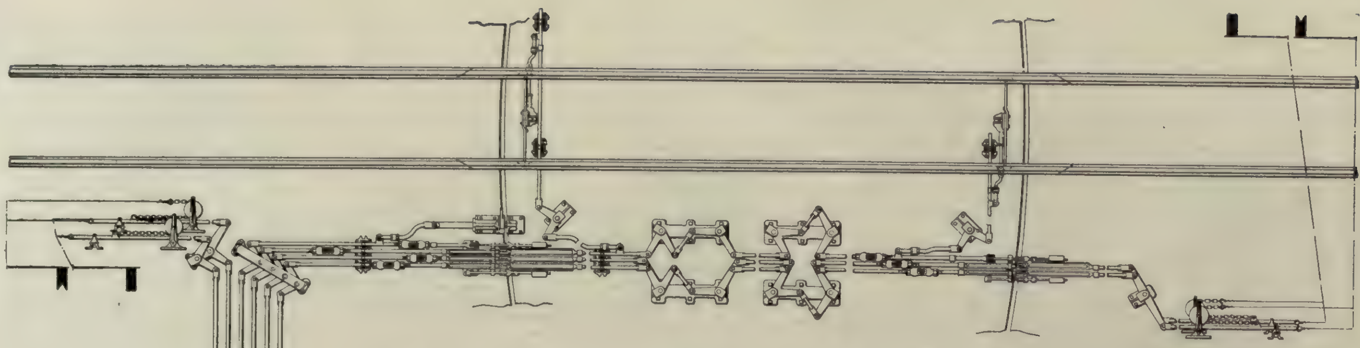


Fig. 1745. Typical Drawbridge Layout; Machine at One End of Draw.

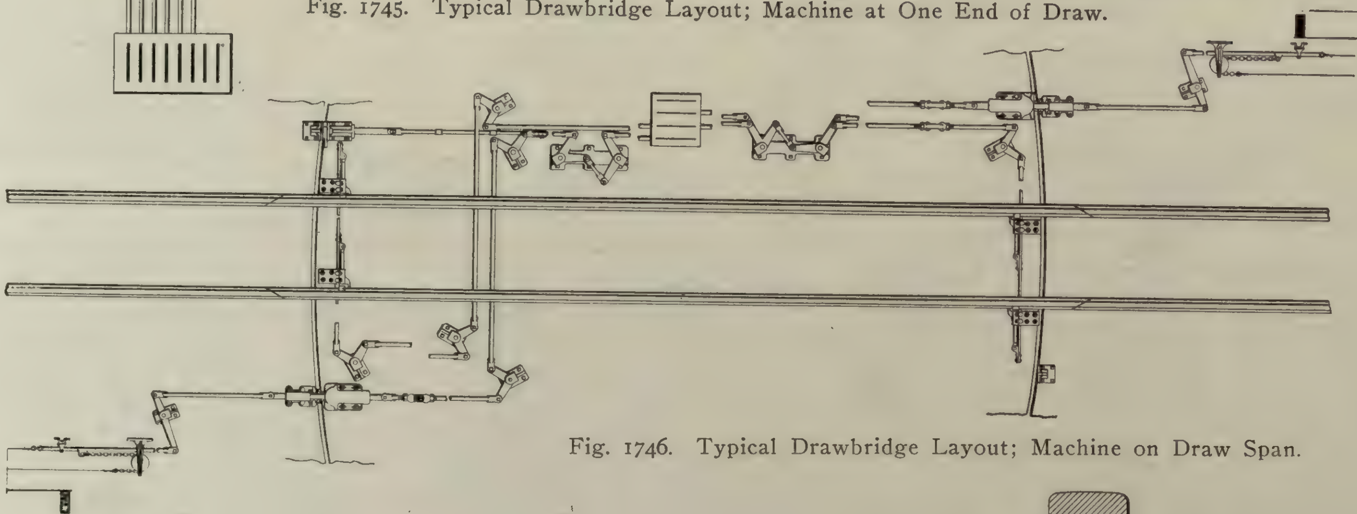
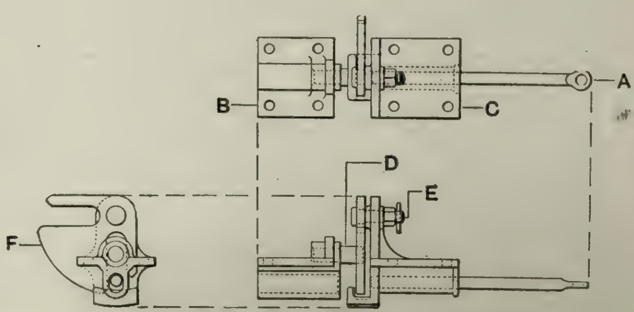


Fig. 1746. Typical Drawbridge Layout; Machine on Draw Span.



Figs. 1747-1749. Gravity Bridge Lock.

Gravity Bridge Lock; Names of Parts of Figs. 1747-1749.

- A *Plunger*
- B *Lock Casting*
- C *Plunger Casting*
- D *Stud*
- E *Stud Bolt*
- F *Escapement Lock*

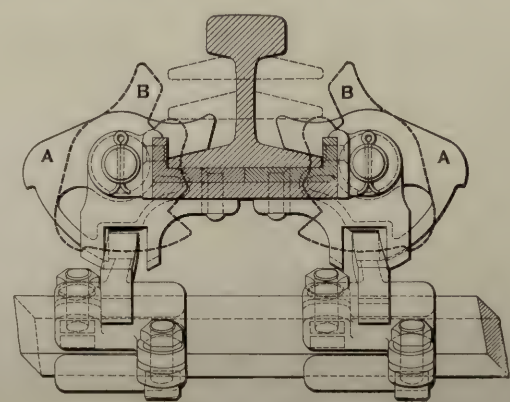


Fig. 1751.

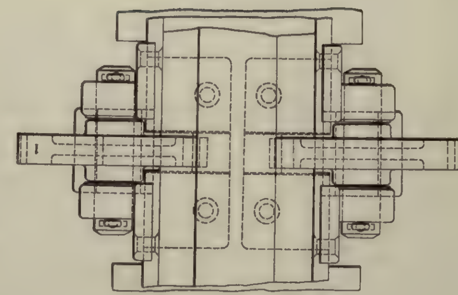


Fig. 1750.

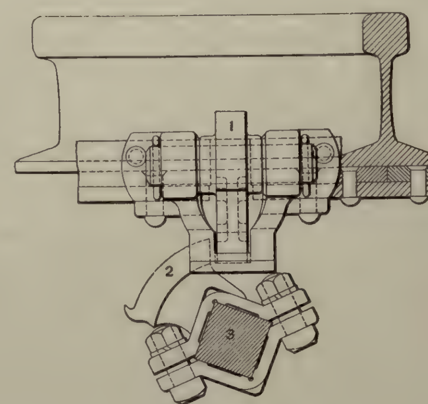
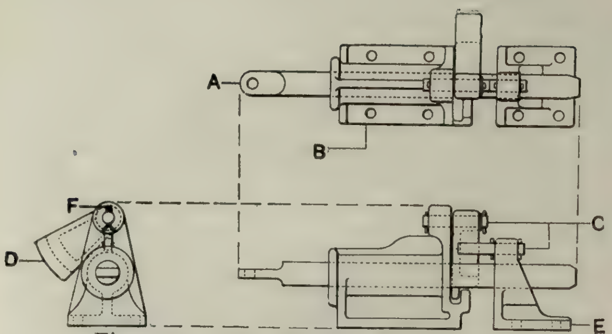


Fig. 1752.

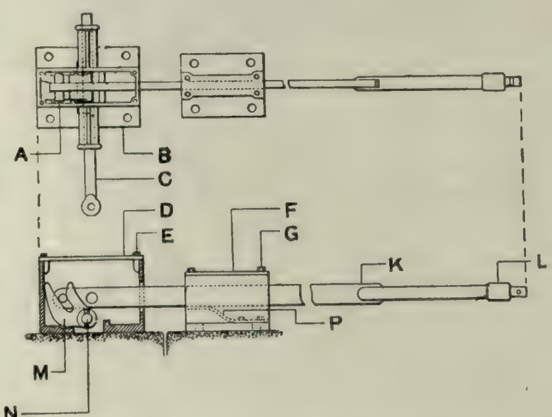
Figs. 1750-1752. The Weaver Drawbridge Rail Lock. T. George Stiles Company.



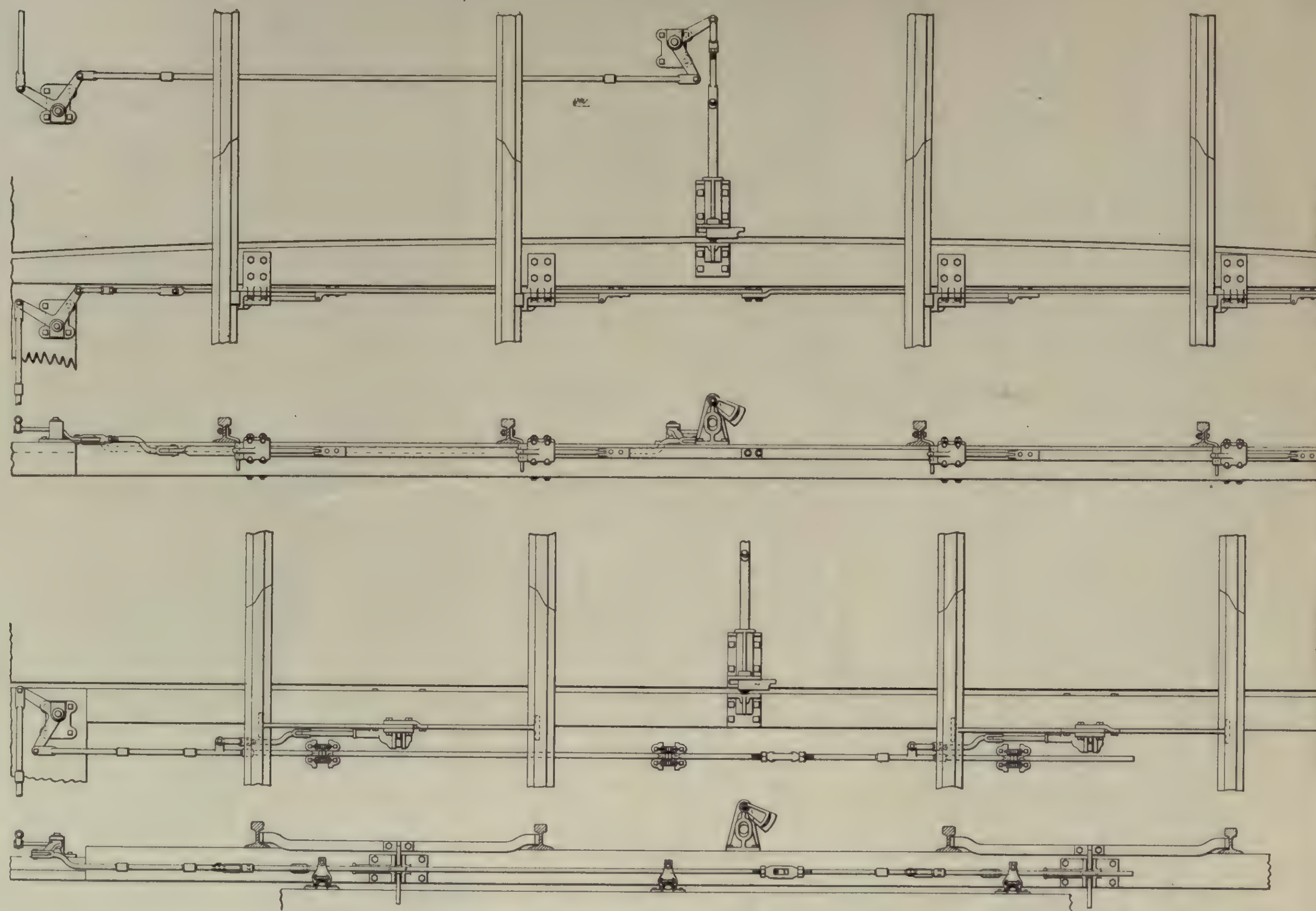
Figs. 1753-1755. Gravity Bridge Lock.

Names of Parts, Gravity Bridge Lock; Figs. 1753-1755.

A *Plunger*
B *Plunger Casting*
C *Pin*
D *Locking Block*
E *Lock Casting*
F *Cotter*



Figs. 1756-1757. Bridge Bolt Lock.



Figs. 1758-1761. Bridge and Rail Locks.

Names of Parts, Bridge Bolt Lock; Figs. 1756-1757.

A *Pin*
B *Plunger Box*
C *Plunger*
D *Plunger Box Cover*
E *Machine Screw*
F *Guide Box Cover*
G *Machine Screw*
K *Tappet*
L *Pipe Sleeve*
M *Escapement Jaw*
N *Pin*
P *Spring*

POWER INTERLOCKING

The earliest system of interlocking employed and that now in most general use is the so-called mechanical interlocking, in which the switches and signals are manually operated by means of interlocked levers connected with them by iron or steel pipe lines or by wire.

The fatigue incident to working mechanical levers at a busy plant is often severe, so that if the plant is large, it is sometimes necessary to employ as many as eight men on each of three shifts of eight hours each. Moreover, under certain conditions it is costly to operate such a plant.

To overcome these and other disadvantages power interlocking has been devised in which the various functions are worked by air under pressure, by electricity or by a combination of the two. With power, switches and signals can be worked at any desired distance from the cabin; the apparatus being so safeguarded that switches must actually be moved and securely locked in the proper position before a signal governing movements over them can be cleared. Each signal, when cleared, automatically locks the lever operating it in such manner as to prevent the release of levers controlling conflicting signals and switches until such signal has been again completely moved to the stop position, thus effectually providing against the simultaneous display of two conflicting clear signals. There being no moving parts between cabin and switches and signals, wear of mechanism, lost motion and the troublesome effects of expansion and contraction of metal connections are eliminated. Much less room is required for leadout connections than in a mechanical plant, valuable space thus being saved. Cabins may be much smaller and of lighter design. The operation at the machine requires so little physical exertion that one man in a power operated plant can perform work that would require several in a mechanical plant.

ELECTRIC INTERLOCKING.

GENERAL RAILWAY SIGNAL COMPANY.

In the General Railway Signal Company's system of electric interlocking, switches and signals are operated by electric motors, the current to actuate them being furnished by a storage battery, usually charged from a dynamo driven by an electric motor or a gas engine. Control of the various functions is effected through an interlocking machine such as is shown in Fig. 1762. The system provides efficient means for preventing the false operation of any unit due to crosses, etc., and positively insures correspondence between the position of any unit and its controlling lever.

The interlocking machine consists of a group of mechanically interlocked levers, to each of which is attached a suitable electric circuit controller for the control of its respective function. During the operation of such a function, the lever is automatically locked in a position of incomplete movement until released by an electro-magnet on its being energized by a dynamic current which is generated by the motor of the operated unit. This dynamic current, or "indication," as it is called, is not generated until a switch has moved to a position corresponding with the lever and has been properly locked in that position, or a signal arm has assumed the full horizontal position. The different levers are interlocked by the means of vertical locking similar in design to the locking in the "Standard" mechanical machine but reduced in size, and in proportion to the number of levers, occupying but a small amount of floor space in the tower. It is arranged to take four bars in each groove of the locking plates, instead of the three used in the "Standard" machine. Fig. 1829 shows the locking as required for the Hudson Terminal installation.

Fig. 1762. Installation of Unit Type Lever Interlocking Machine (Model 2), Lake Street Tower. Chicago Terminal. C. & N. W. Ry., General Railway Signal Company.

Two views of the Model 2 interlocking machine are shown in Fig. 1763,—a front view showing the locking and a sectional view showing a switch lever with its controller, etc. Fig. 1764 shows front and sectional views of portions of the fuse and terminal board. The machine, in general, consists of the framework, the cabinet, the terminal and fuse board, the locking and the levers with their guides, magnets and circuit controllers.

The locking plates are furnished in tiers to a maximum of three, the number of tiers depending upon the complications in the locking required. When more than three tiers of locking are necessary, a special form of leg has to be furnished to accommodate the extra locking plates.

The cabinet completely encloses the machine with the exception of the terminal board and grips of the operating levers. Removable panels in the front of the cabinet give easy access to the locking, and panels in the back and glass covers on the top give access to the levers, controllers, etc. The glass covers are generally locked or sealed to prevent unauthorized manipulation or tampering with the parts.

A slate terminal board is provided for making the connections between the interlocking machine and the external wires. On this are mounted the switch and signal bus bars, indication bus wires, polarized relays, fuses and binding posts. The various incoming wires, those from the operating switchboard and the wiring of the machine proper, terminate on the binding posts or fuse posts as the case may be, the arrangement being such that any wire or other electrical part may conveniently be disconnected for testing purposes. The connecting wires running from the terminal board to the various controllers are made up in sets formed to fit, and taped together. Terminals and fuses for each lever are directly under it and are numbered and lettered to correspond.

A view of a switch lever assembled with its controller, safety and indication magnets is shown in Figs. 1765-1766. The lever, which is known as the "Unit Type," is so designed that it may be removed with its guide and indication magnet, without moving its tappet from the normal position or disturbing adjacent levers in any way. The lever is provided with a cam slot U which gives the necessary motion to the tappet V to operate the locking. The dotted circles, 1 to 5 in the cam slot, indicate the position of the tappet roller which corresponds with like numbered positions of contact block Z, the lever being rigidly connected to the contact block by the rod W. During the first part of its travel, the lever moves the tappet bar through one-half of its stroke by means of the cam slot. During this portion of the movement, no change is made in the electrical connections, as the contact block slides along the same brushes. This preliminary tappet movement locks all other levers conflicting with the new position of the lever in question. The middle part of the travel of the lever carries the contact block from brushes at one end of the controller to the brushes at the other end. During this part of the travel, the tappet bar remains stationary and the lever is brought to stop by projection J on the latch L, having engaged with tooth Q on the lever (see Fig. 1766), the lever being held thus until released by indication magnet I.

The method by which a switch lever is prevented from completing its stroke until the function controlled by such lever has assumed a position corresponding therewith will be understood by the following changes which take effect as the lever is moved through its complete stroke. Fig. 1765 shows the lever normal and 1766 shows it resting against the indication stop (position 4). In passing from position 1 to 2, the projection M on lever D coming against projection K on latch L causes the latch to assume the reverse position as shown in 1766, bringing projection J into path of tooth Q. In moving from position 2 to 3 the tooth Q, coming in contact with a similar projection on the cam N, causes it to revolve into the horizontal position, shown dotted in 1766, thus forcing dog P into the position shown in 1766 and locking latch L in its horizontal position. In moving from position 3 to position 4 the cam N is revolved into the position shown in full lines in 1766 and the lever is stopped at position 4 by the tooth Q coming

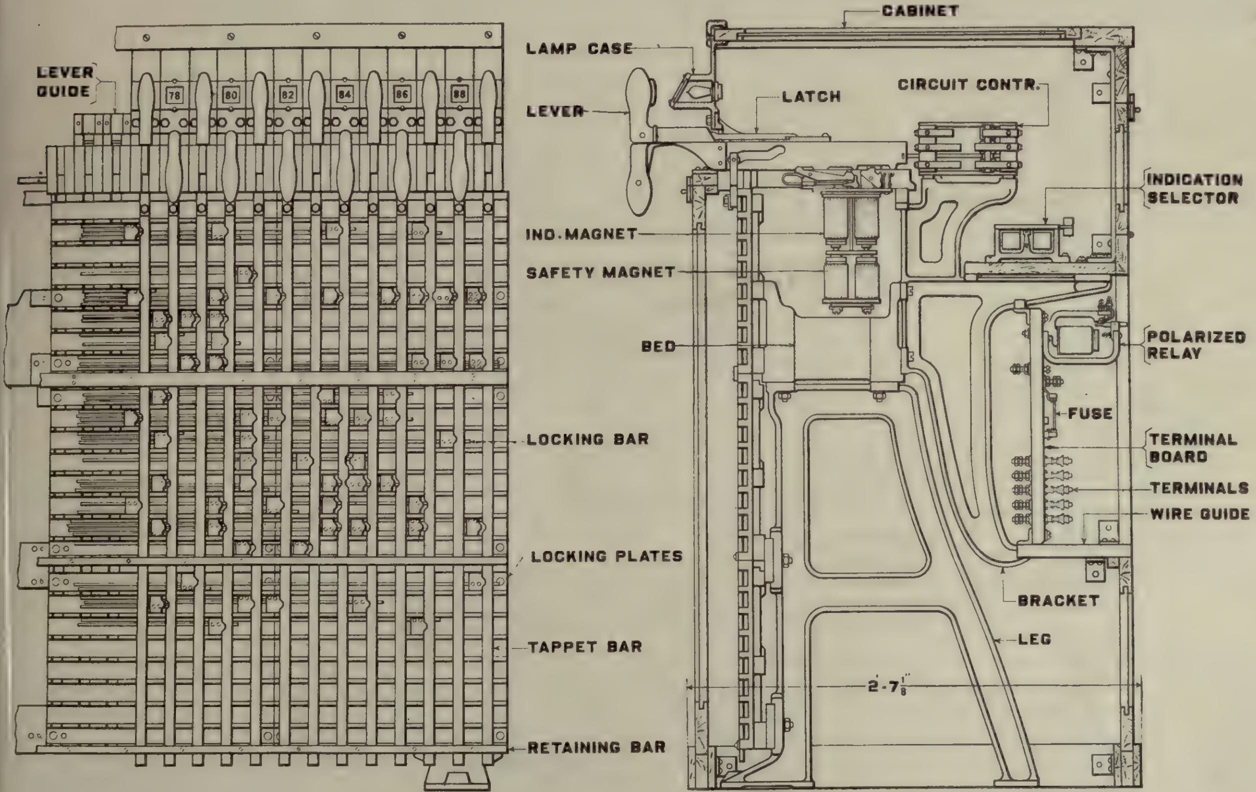
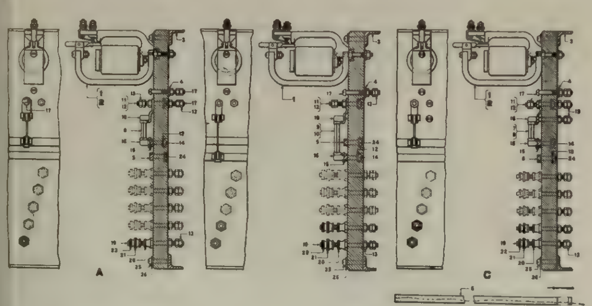


Fig. 1763. Unit Lever Type Electric Interlocking Machine (Model 2). General Railway Signal Company.



High Signal or Model 2A Dwarf. Switch. Solenoid Dwarf.

Fig. 1764. Terminal Board Arrangement Model 2 Electric Interlocking Machine.

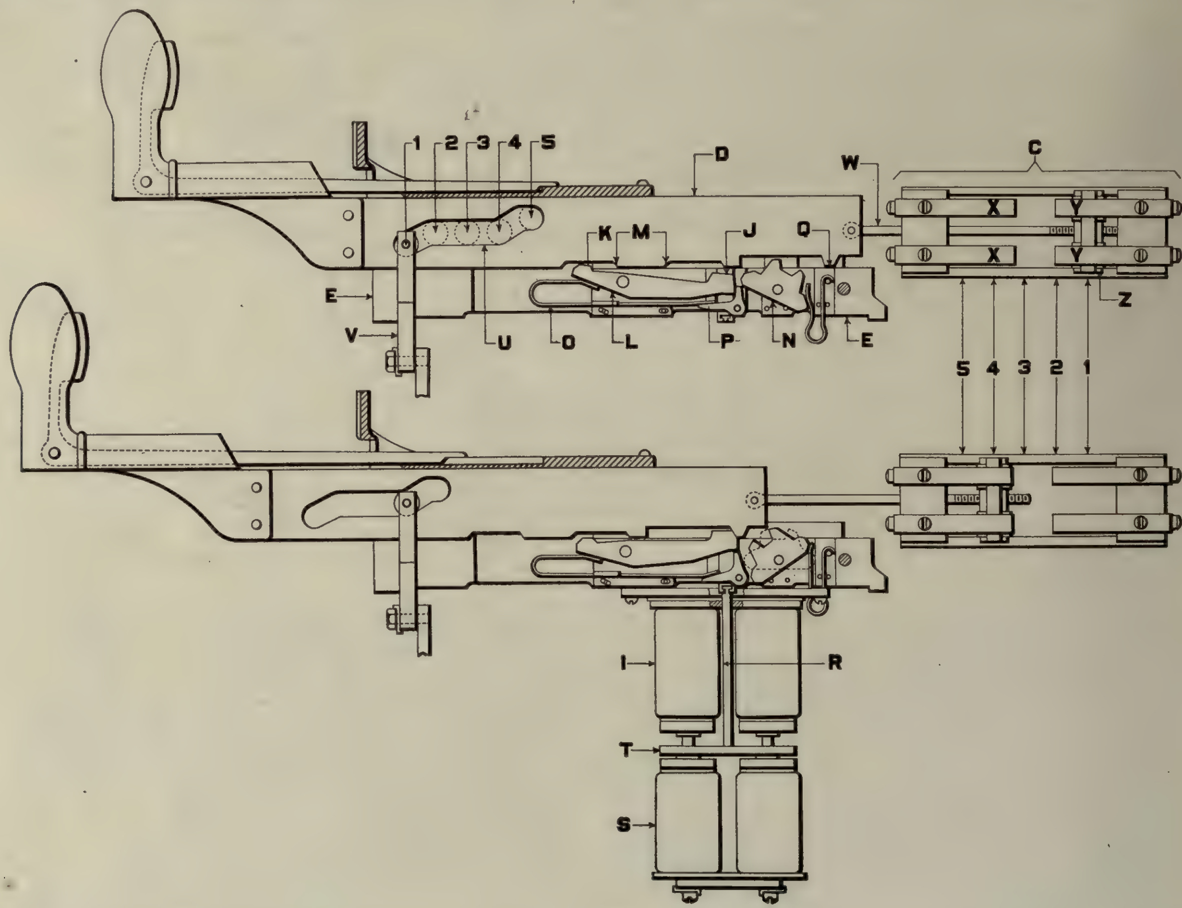
against projection J. Meanwhile the contact block Z having come into contact with brushes X-X completes the battery circuit to the motor, causing the switch to be operated and locked in position. The indication current is then sent through magnet I, lifting armature T and causing plunger R to strike dog P and throw it out from under latch L. The latch, being thus released, drops to its normal position shown in G, and permits lever movement from 4 to 5, thus completing the stroke, which, by lifting tappet V, releases all levers not conflicting with the new position of switch. The stroke from reverse to normal acts in the same way. A switch failing to complete its movement owing to some obstruction in the switch point, or for any other cause, may be restored to its original position, and its lever operated back and forth, thus frequently dislodging the obstruction, thereby preventing a tie-up and incidental detentions. The lever, however, can neither be placed fully normal nor fully reversed without the proper indication being received, showing that the switch has been locked in the position corresponding with that of the lever.

Levers for signals operate in the same manner with the exception that the lever is allowed to pass to the full reverse position 5, without an indication being received, since an unsafe condition does not result if the signal for any reason fails to clear.

Fig. 1767 shows diagrammatically the apparatus required at a typical interlocking plant, and the circuits for same. A generator with suitable driving power and storage battery of proper capacity are required to supply the energy necessary for the operation of the plant. The switchboards shown are in accordance with the G. R. S. Co's. latest practice, the operating board being equipped with an improved type of cross-protection circuit breaker. The power board is used to regulate and safeguard the circuit from the generator to the battery and from the battery to the operating board, and the operating board to distribute and protect the circuits to the interlocking machine and the apparatus.

The power board (Fig. 1768) is arranged to serve the interlocker from the generator direct or from the battery during either the period of charging or discharge. An ammeter and voltmeter controlled by suitable switches are provided to record the charging or discharge current and the battery or generator voltage respectively. Connected in series with the generator field and mounted on the back of the board is a rheostat giving the variable resistances required to regulate the charging current delivered from the generator to the battery. A "no-load reverse current" circuit breaker CB safeguards the generator against running as a motor should the generator voltage drop below that of the battery.

Fig. 1768 gives the general appearance of the operating switchboard with its equipment of circuit breaker, voltmeter, ammeter, ground detector lamp and switch, and indication red light. Fig. 1770 shows cross-sections of the circuit breaker CB[1].



Figs. 1765-1766. Diagram Showing Operation of Unit Type Lever (Model 2 Interlocking Machine). General Railway Signal Company.

The circuit breaker CB[1], which operates on the closed circuit principle, is so controlled that it will be opened by the improper application of current to any unit, thereby cutting off all operating current from the interlocking plant. It, furthermore, is designed to prevent the restoration of power to the plant until such time as the cross has been removed. All contacting parts of the circuit breaker are under a sealed case with only the restoring handle projecting out within reach of the leverman. In case the circuit breaker opens, the operator first attempts to eliminate the cause of the trouble, then, grasping the restoring handle, raises it to its upper stop, at once restoring it to its normal position. If the trouble has not been remedied, the circuit breaker immediately opens again. Should the operator attempt to plug the circuit breaker or to hold it in, he will accomplish nothing more than to keep the plant inoperative until the proper correction has been applied.

The coils of the circuit breaker CB[1] are controlled in series through the points of the polarized circuit breakers or relays H^1, H^2, H^3 and H^4, which are mounted upon the terminal board of the interlocking machine. Referring to Fig. 1767, it will be seen that each function is protected by one of these relays, the current which passes through its coils during the proper operation of such a function always taking the same direction. A current from an unauthorized source would have two paths to follow, one tending to operate the function and the other through the polarized relay H_X in the direction tending to reverse its armature, thereby opening the control circuit of CB[1] on the operating board. Circuit breaker CB[1], immediately opening, cuts off all power from the plant and prevents the restoration of power until the removal of the cross

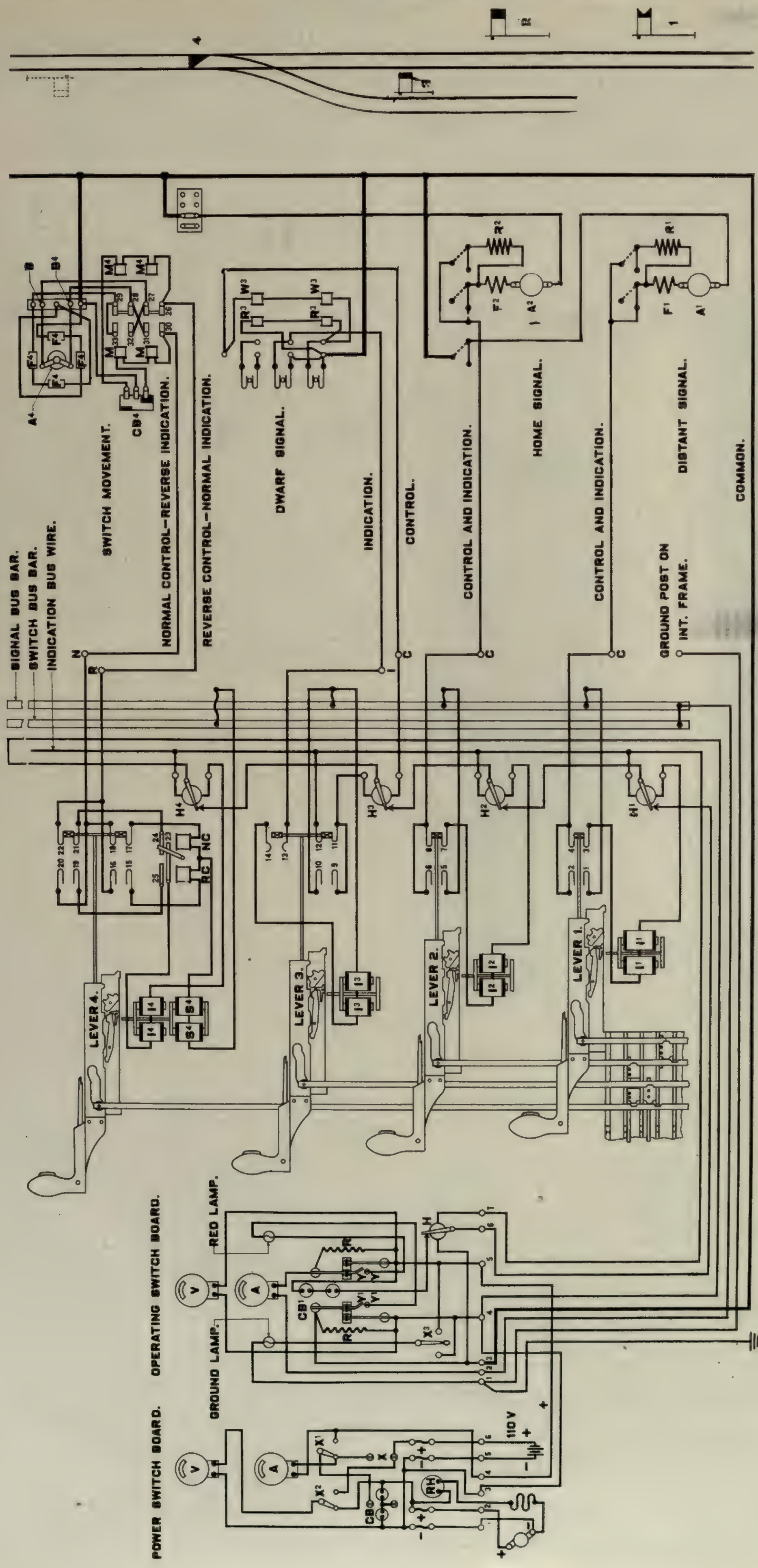


Fig. 1767. General Circuits for All-Electric Interlocking Plant. General Railway Signal Company.

the operator being notified of the existent trouble by the red lamp which is lighted through the closing of circuit breaker contacts, Y-Y and Y^1-Y^1. The control circuit of the circuit breaker coils also breaks through the point of polarized relay H, located on the operating board, this relay acting as a circuit breaker to prevent the blowing of the main fuses on the power switchboard in case of an accidental short circuit between the positive bus and the indication bus on the interlocking machine.

It will be noticed that both the positive and negative connections between the power board and interlocking plant are broken through the blades of the circuit breaker. This permits full measure of protection in case it is desired to sectionalize the interlocking plant so that the operation of only

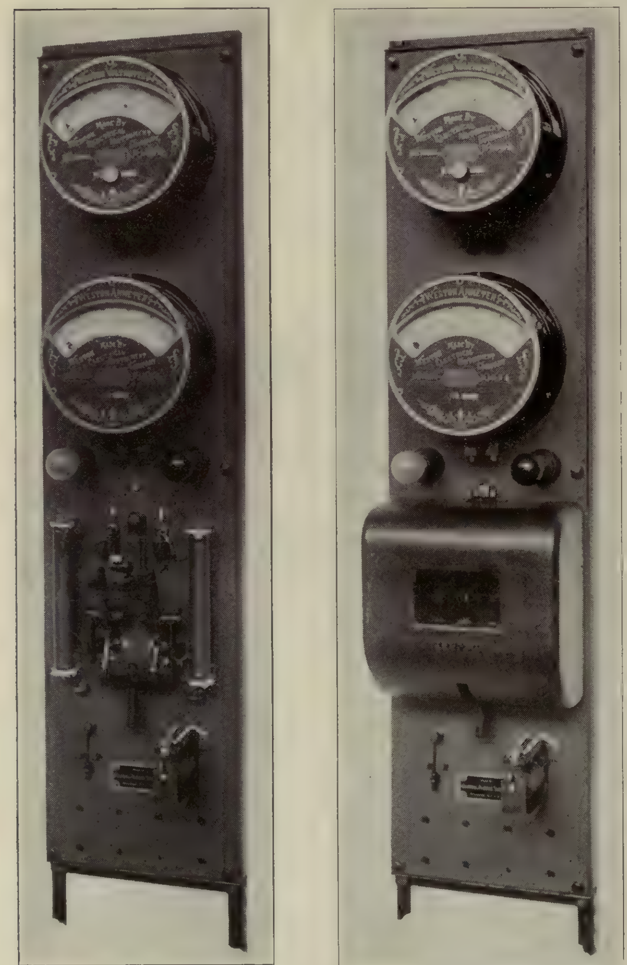


Fig. 1768. Operating Switch Board (Improved Circuit Breaker). General Railway Signal Company.

that part of the plant immediately concerned will be interfered with in case of trouble.

The ground detector switch X^3, by lighting the white lamp, gives indication of a ground on the positive or negative wires on being thrown to the left or right contact respectively.

The switchboard if desired will be provided with resistance units which are arranged to permit the flow of sufficient current to hold such signals in a clear position as were so displayed when the circuit breaker opened. Due to the resistances, sufficient potential will not exist at the bus bars, with the circuit breaker CB^1 open, to permit the operation of any function.

In Fig. 1767 levers 1 to 4 inclusive are shown with suitable circuits for the control of G. R. S. Co. Model 2A distant and home signals, solenoid dwarf signal and Model 2 switch movement.

The switch movement is controlled by two wires in addition to the main common wire, the current generated by the switch motor itself being transmitted through the common wire and either one of the two control wires. In one position of the lever, one of these wires is the control and the other is the indication wire, while in the other position these conditions are reversed. One of these wires is connected to the positive terminal of the battery through the coils of the indication selector and those of safety magnet S^4 to the switch bus bar, and the other wire is connected to common through the contacts on the indication selector, the coils of indication magnet I^4, coils of the polarized relay H^4, the indication bus wire, post 7 of the operating board, coils of polarized relay H to post 3 of the operating board; when the lever is reversed, these connections are reversed also.

Indication selector RC-NC (Fig. 1767) is arranged in such a manner that energy flowing through the operating wires attracts the armature and closes the contacts for the reverse indication when the reverse operating wire is energized and for the normal indication when the corresponding operating wire is energized.

The safety magnet S^4 is placed beneath indication magnet I^4, the indication armature resting normally on the pole pieces of the safety magnet. By referring to circuits, Fig. 1767, it will be seen that a cross between the two control wires could in no case cause the current flowing through the indication coils to exceed that flowing through the safety magnet; and since the armature rests upon the safety magnet and is a quarter of an inch away from the indication magnet, an indication cannot be effected. The safety coils being connected in series with the control circuit, a break in any of the wires concerned would cut off current from the function.

The circuit controller P or pole changer is placed at the switch, and is operated automatically through the medium

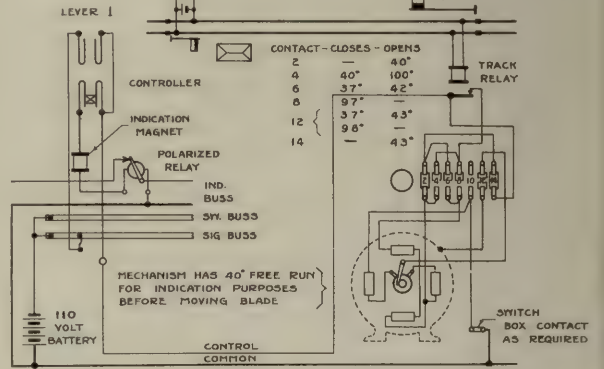


Fig. 1769. Circuit for Model "2A" Semi-Automatic Interlocking Signal. (Dynamic Indication.)

of the mechanical movement I (Fig. 1780), by the lock plunger in the last part of its stroke after it has passed through the lock rod and locked the switch. The arrangement of this mechanical movement is such that two pins mounted upon the lock rod M shift the point of fulcrum in the mechanical pole changer movement, so that, with the same movement of the lock plunger, the pole changer contacts are thrown first in one direction and then in the other direction, their position corresponding to the position which the switch points have assumed. The electrical connections are such that in one position of the pole changer, terminal B of the armature is connected to the control wire and terminal B^4 to the field coils, while in the other position, terminal B^4 is connected to the other control wire, and terminal B to the field coils. The operation of the pole changer accomplished three objects:

(1) To cut current off from the motor; (2) to reverse the armature connections; (3) to complete the indication circuit, at the same time leaving the proper circuits set up for the next movement of the switch machine.

The pole changer, furthermore, is under the control of two sets of magnets, so that, should the switch fail to complete its movement and give the necessary indication, the position of the controlling lever may be shifted, and through the energizing of one or the other of the sets of pole changer magnets cause the pole changer to assume a position corresponding to that taken by the lever. This accomplishes the object of setting up the proper circuit for the operation of the switch movement in any desired direction. It will be seen that this feature places the switch so under the control of the leverman that, should the points be blocked with snow, etc., the operator may work the controlling lever back and forth, frequently dislodging the obstruction, thereby permitting the desired movement of the switch to be completed.

Circuit breaker CB^4 (Fig. 1767), shown in the diagram, is operated automatically by the switch movement and cuts off current from the magnets M-M when the switch is normal, and from M^4-M^4 when the switch is reversed, this taking place only when switch is home and securely locked in position.

In the diagram (Fig. 1767), all functions are shown in the normal position. By reversing lever 4, the reverse operating wire is placed in connection with the battery, causing current to flow from battery through the safety and control devices on the power and operating boards to the switch bus bar, fuse, safety magnet S^4, indication selector coil RC, circuit controller contacts 15-16, the reverse control wire, pole changer contacts 26-27, switch motor armature A^4, pole changer contacts 28-29, field coils F^4, to main common and back to the control wire for the other operation), pole changer contacts 30-31 to the terminal B^4 of the armature, thereby energizing indication magnet I^4 and tripping the indication mechanism as explained in the operation of the lever (pages 211-212).

Placing lever 4 in the normal position again connects the normal control wire with battery, causing current to flow through safety magnet S^4, coil NC of indication selectors, contacts 17-18 of switch circuit controller, normal control wire, pole changer contacts 30-31 to armature terminal B^4, through

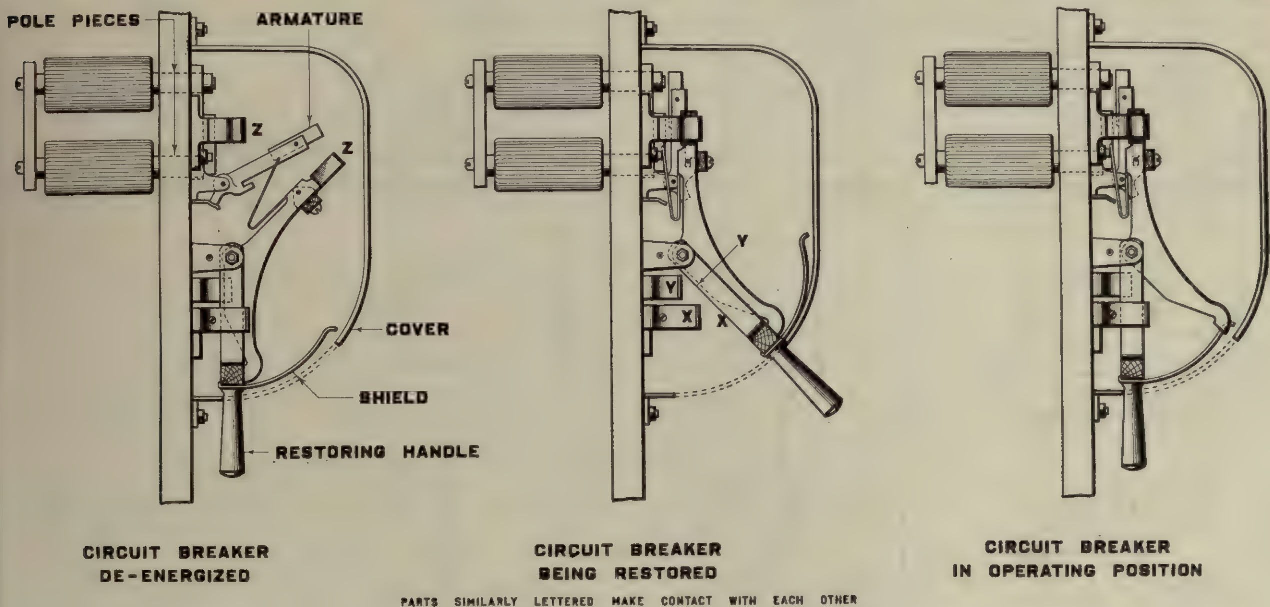


Fig. 1770. Sectional View of Operating Switch Board Circuit Breaker. General Railway Signal Company.

negative side of the battery. The motor operates the switch mechanism, and, when the switch has completed its movement, the lock plunger changes the pole changer from contacts 26-27 to contacts 30-31 and from contacts 28-29 to contacts 32-33, thereby disconnecting the reverse control wire from the circuit, connecting in the reverse indication wire and reversing the armature's relation with its fields.

An electric motor when driven by a current tends to develop an electro-motive force in opposition to the driving the armature in the opposite direction to that taken in the reverse operation of the switch, thence through the fields to common. The armature rotation is consequently reversed and the switch points move back to their normal position. At the end of the movement, the pole changer P is shifted back to the position shown in the diagram and the indication current is generated as before, leaving the terminal B^4 and returning to the terminal B through the normal indication wire.

Fig. 1771 shows diagrammatically the cycle of operation of a

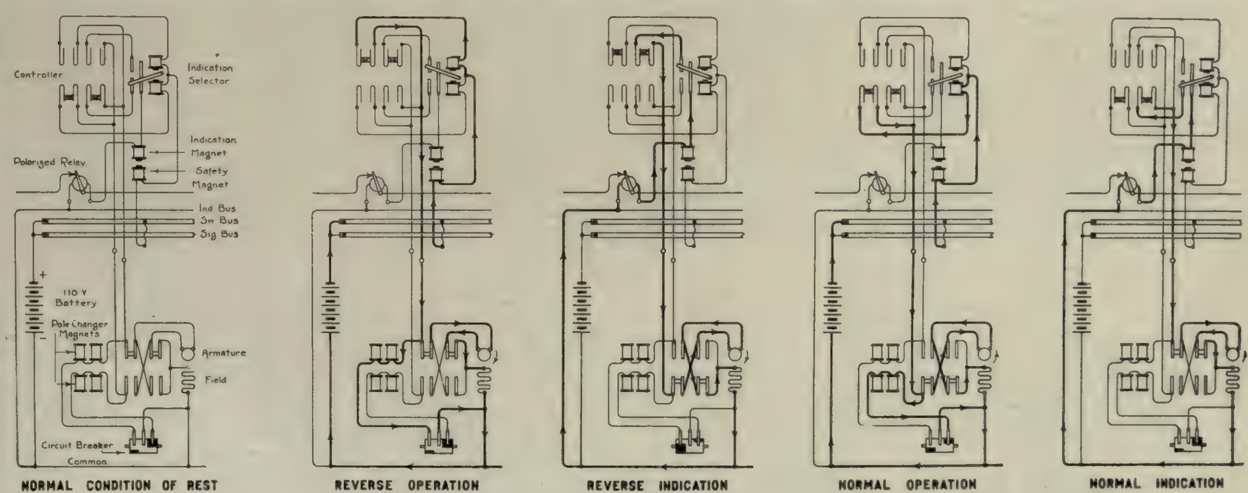


Fig. 1771. Operation of Electric Switch Machine. General Railway Signal Company.

electro-motive force, and, after the current is cut off, the armature continues to rotate from acquired momentum and continues to develop this electro-motive force. The new connections made by the pole changer as above described are such that the electro-motive force thus developed sends a current from the armature at terminal B, which passes through the field coils in the same direction as the driving current flowed, thus maintaining their magnetization, through the main common to post 3 on operating board, coil of polarized relay H, post 7 on operating board, indication bus wire, coil of polarized relay H^4 on interlocking machine, indication magnet I^4, contacts of indication selector 23-25, contacts 19-20 of controller, reverse indication wire (which is the normal switch function, the wires carrying current being shown heavy, and the direction of current by the arrow heads.

When it is desired that two switches be operated together, for instance both ends of a cross-over, a special short lever is used for one and a standard lever for the other, these two levers being placed next to each other in the machine and connected by a plate, so that they move together.

Home signal No. 2 is controlled by a 110-volt, non-automatic Model 2A mechanism, dynamic indication. Lever 2, on being reversed, causes current to flow from the signal bus bar through lever contacts 5-6, the control wire, signal armature and field, thence through normal contact on switchbox to main common, thereby clearing the signal. At the proceed position

high-resistance retaining coils are cut in series with the operating coils, thus reducing the hold clear current to a minimum. The reverse indication is not required, as it is not an unsafe condition if the signal fails to go to the proceed position.

When the lever is placed at the normal indication point, the

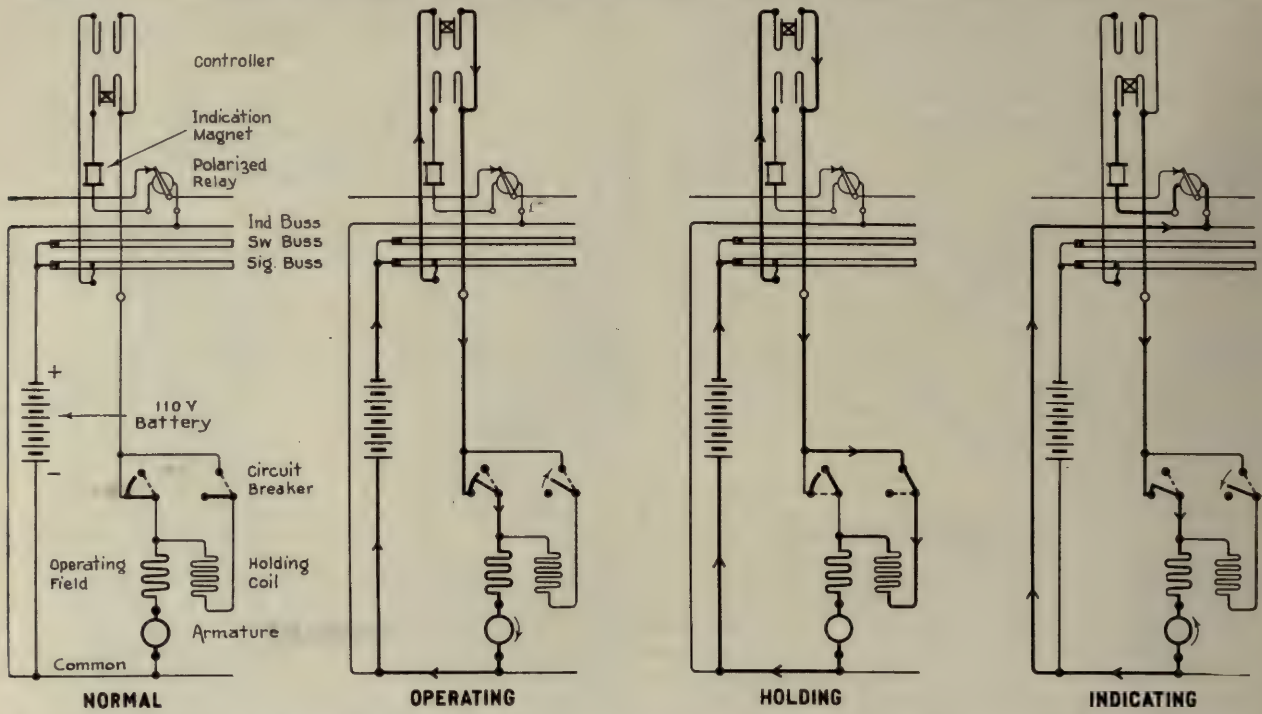


Fig. 1772. Operation of Model "2A" Signal. Dynamic Indication, Non-Automatic Control. General Railway Signal Company.

circuit is broken at signal controller contacts 5-6, and by the closing of contacts 7-8 the control wire is connected with the indication magnet, and through the polarized relay H² to the indication bus wire. The signal, in returning to the normal posi-

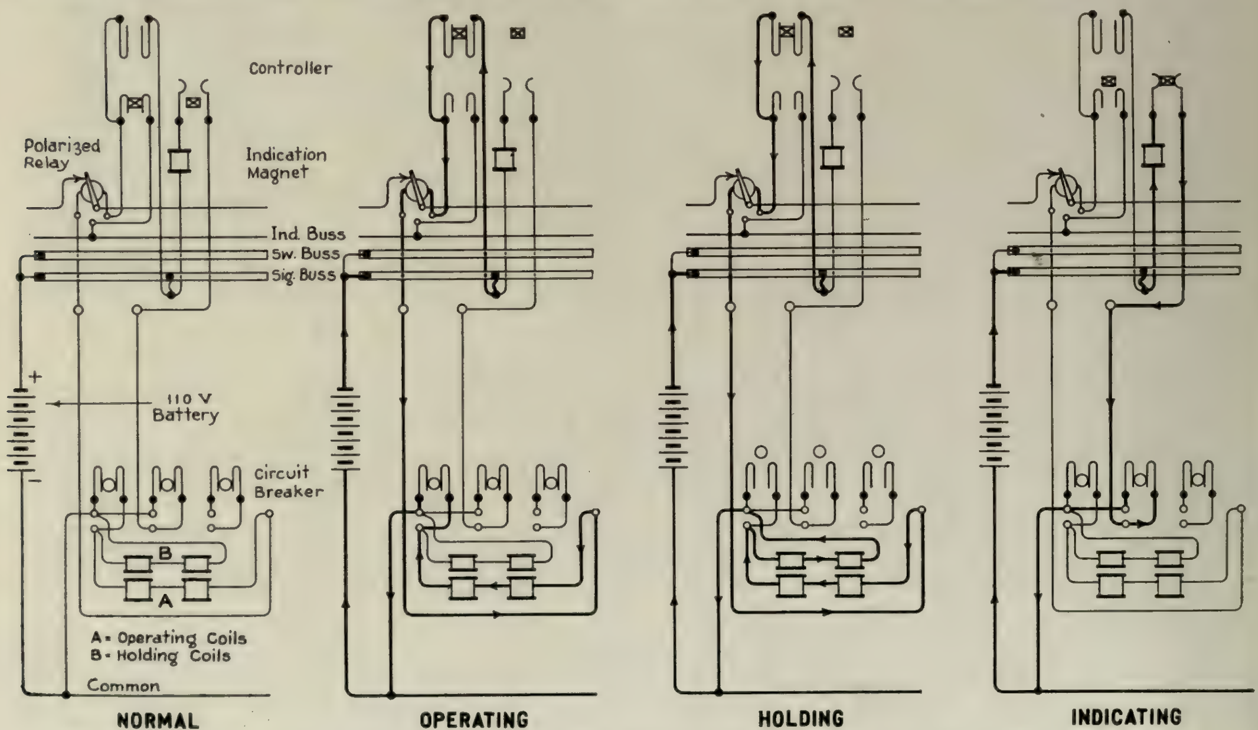


Fig. 1773. Operation of Solenoid Dwarf Signal. General Railway Signal Company.

tion, drives the armature in the direction opposite to that taken while clearing, and, when a few degrees from the normal position, through the closing of a contact on the signal circuit breaker, the motor is placed on the following closed circuit: From the motor, through main common, post 3 of operating switchboard, coil of polarized relay H, post 7 of the operating board, indication bus wire, polarized relay H², signal controller contacts 7-8, indication magnet I² and signal control wire, and back to the motor. Due to its momentum, the motor immediately generates an E. M. F., forcing a current through the closed circuits described above, tripping the indication mechanism on the controlling lever, thereby allowing it to be restored to the full normal position. The building up of the E. M. F. checks the momentum of the armature and brings the signal mechanism to rest without shock.

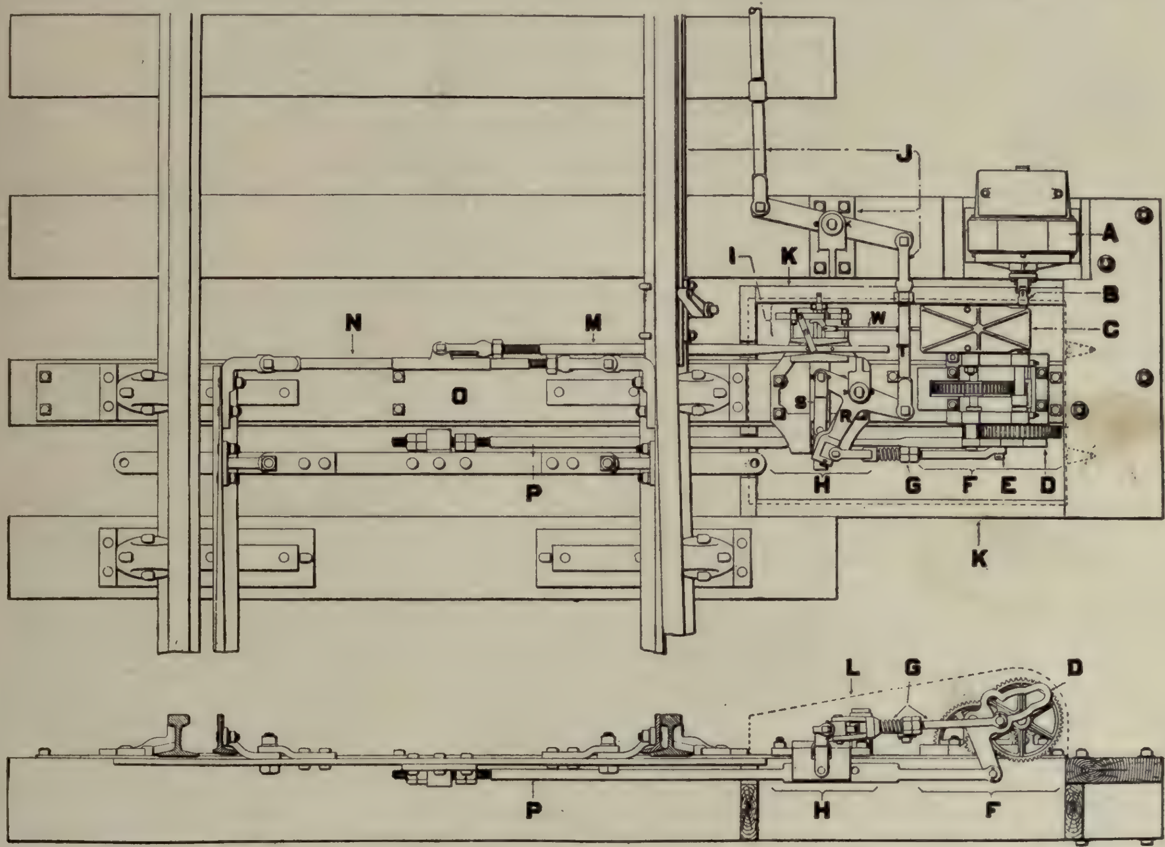
When it is desired to have the signal controlled semi-automatically, the mechanism differs from the other in that the first part of the movement does not affect the position of the blade, but puts under tension set of coil springs which are strong enough on the normal movement to rotate the motor backward

with sufficient speed to generate current for tripping the indication mechanism on the lever. Should the track circuit be occupied, the controlling lever being reversed, the mechanism will be held with the springs under tension just as this type of mechanism is held at any of the proceed positions of the blade. Should the track circuit, however, be unoccupied, the signal mechanism will continue its movement, carrying the blade to the proper proceed position, its operation from this point on being similar to the regular Model 2A mechanism,

The distant signal is operated and the indication current generated in the same manner as described for home signal No. 2, the operation being controlled by lever 1 and circuit controller on the home signal mechanism.

Dwarf signals may be operated by a Model 2A mechanism, having either non-automatic or semi-automatic control, the same as the high signals just described, or the dwarf may be of the solenoid type, such as is controlled by lever 3 in Fig. 1767.

The solenoid dwarf (Fig. 1767) is provided with a sole-



Figs. 1774-1775. Model 2 Electric Switch and Lock Movement. General Railway Signal Company.

Names of Parts, Electric Switch and Lock Movement; Figs. 1774-1775.

A *Motor*	**H** *Lock Movement*	**N** *Front Rod*
B *Connecting Shaft*	**I** *Pole Changer Movement*	**O** *Tie Plate*
C *Pole Changer*	**J** *Detector Bar Operating Mechanism*	**P** *Throw Rod*
D *Cam Crank*		**R** *Lock Crank*
E *Driving Pin*	**K** *Long Ties*	**S** *Lock Link*
F *Gears and Frame*	**L** *Outline of Cover*	**T** *Detector Bar Driving Link*
G *Driving Rod*	**M** *Lock Rod*	**W** *Pole Changer Rod*

Fig. 1776. Lock Plunger; Locks Both Lock and Throw Rods.

Fig. 1777. Link S, Figs. 1774-1775.

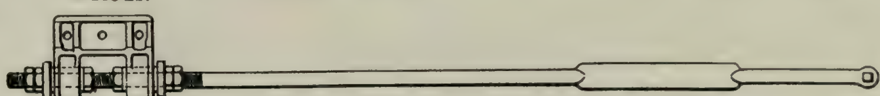


Fig. 1778. Throw Rod, with Tappet for Lock Plunger. See H, Fig. 1774.

previously described. It will be noticed that the first 40-deg. movement of the mechanism is always under the control of the operating lever, its circuit not being broken through the track relay as is that which controls the actual movement of the semaphore arm, consequently a dynamic indication may be obtained any time the lever is restored to the normal position, regardless of train movement. The circuit breaker of the signal is so wired that, a train having accepted and put the signal to block, it will be necessary to place the controlling lever full normal and reverse it again before a second clearing of the signal may be accomplished.

noid having two sets of windings, working coils of low ohmic resistance and retaining coils of high resistance. As it is impracticable to secure a dynamic indication from a dwarf of the solenoid type, battery indication is required. The signal, therefore, needs for its operation an indication wire in addition to the usual control wire. Lever 3, on being reversed, causes current to flow from the signal bus bar through the dwarf lever contacts 9-10, the control wire and the working coils W-W of the dwarf to common. Upon the signal arm assuming the proceed position, a circuit breaker on the signal proper cuts the retaining coils R-R in series with the operating

Fig. 1779. Driving Rod G. Model 2 Switch.

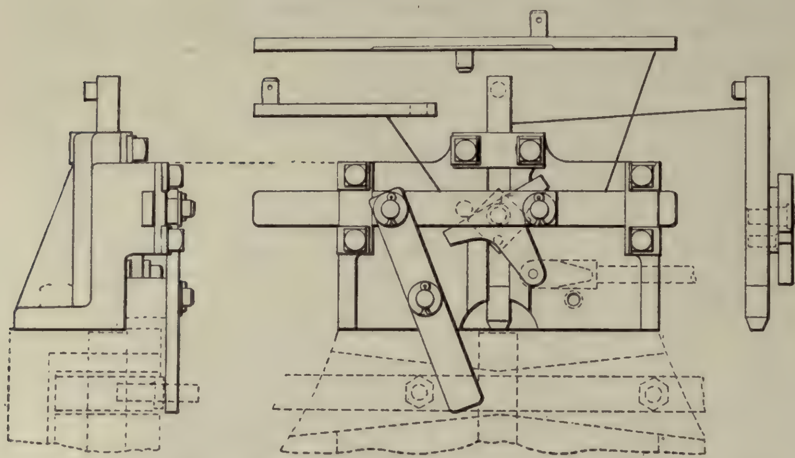
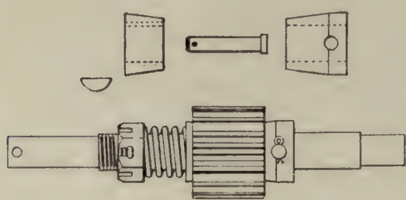


Fig. 1780. Pole Changer Movement I. Model 2 Switch.

Fig. 1781. Commutator V. Fig. 1787. Model 2 Switch.



Figs. 1782-1786. Friction Clutch. Model 2 Switch.

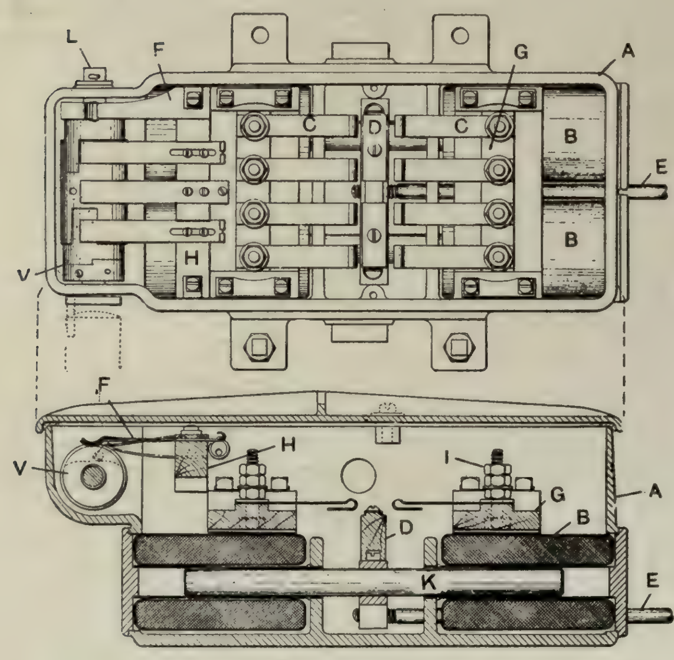


Fig. 1787. Pole Changer. Model 2 Switch.

Fig. 1788. Tie Plate, with Slot for Gear Wheel O. Model 2 Switch.

Names of Parts, Pole Changer; Fig. 1787.

A *Case*	**E** *Operating Rod*	**I** *Binding Posts*
B *Solenoids*	**F** *Snap Spring*	**K** *Armatures*
C *Contact Springs*	**G** *Contact Block*	**L** *Shaft*
D *Contact Block*	**H** *Contact Block*	**V** *Commutator*

coils, thereby reducing the holding current to the lowest point at which the signal blade can, with certainty, be held in the clear position. As in the case of the high signal levers, the lever controlling the solenoid dwarf is designed to pass to the full reverse position without receiving an indication. When the lever 3 is pushed back to the normal indication point, the circuit through the retaining coils is broken and the signal arm returns to the stop position. A circuit controller on the signal, which is closed only at full normal position, allows current to flow from the signal bus bar through the indication magnet, lever contacts 13-14, indication wire, to the circuit con- plunger, this movement being a completion of the stroke locking the switch in either its normal or reverse position. By the pole changer movement (Fig. 1780) the pole changer C is caused to throw in one direction when the switch has reached its normal position and in the other when the switch has reached its reversed position, such movement of the pole changer opening the operating circuit and closing the circuit for the indication. As explained in the preceding paragraph, the pole changer is under the control of the lever, excepting when the switch is locked in either normal or reversed position, through the medium of the pole changer magnets M-M and

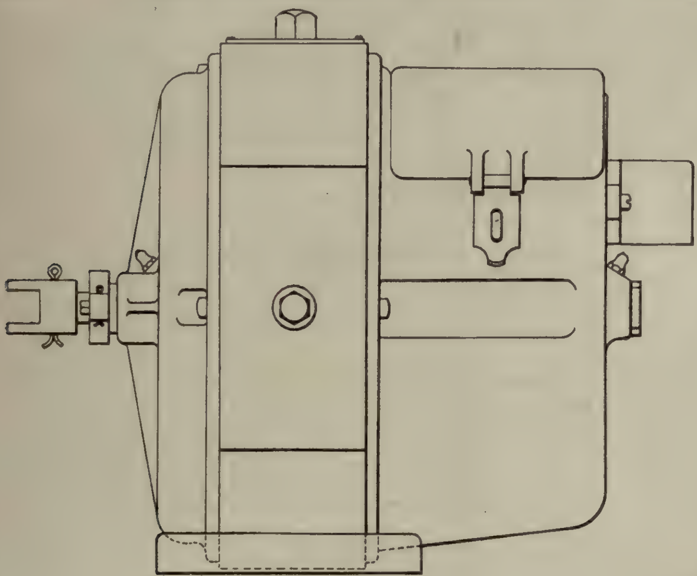


Fig. 1789. Motor A.

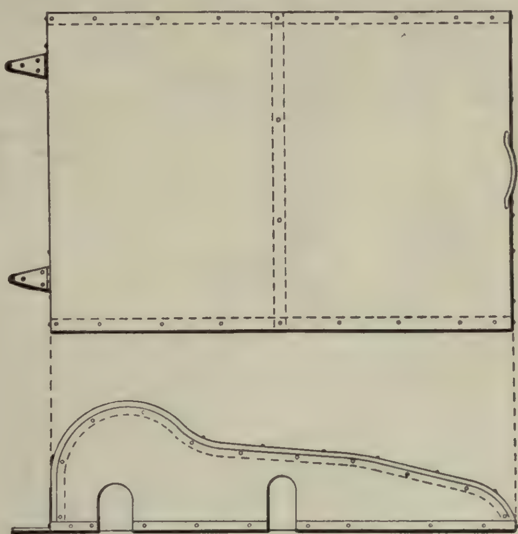


Fig. 1790. Switch and Lock Movement Cover L.

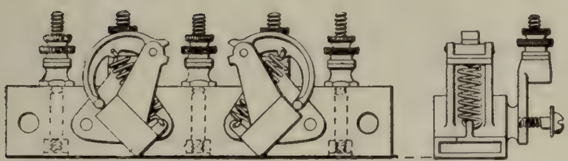


Fig. 1791. Motor Brush Holder.

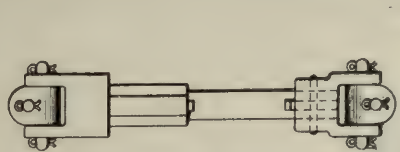


Fig. 1792. Connecting Shaft B.

Figs. 1789-1792. Parts of Model 2 Electric Switch and Lock Movement, Figs. 1774-1775. General Railway Signal Company.

troller in question and to common, thereby tripping the indication mechanism and allowing the lever to be placed full normal. Contacts 13-14 are designed to make contact only at the indication point so as to prevent unnecessary waste of current or heating of the coils. Cross protection is held through stub normal contacts 11-12.

The Model 2 type of electric switch and lock movement, when connected to a single switch, is shown in Figs. 1774-1775. It consists of the following essential parts: motor, pole-changer, gear frame and lock movement. The gear frame is arranged to simultaneously raise the detector bar and withdraw the lock plunger. After the unlocking is fully accomplished, the switch points are thrown, this movement being followed by the simultaneous lowering of the detector bar and the locking of the switch in its new position. The gear frame is designed to further allow the switch motor to continue on several revolutions, thereby generating the indication current, which at the same time checks the speed of the motor and brings it to rest without shock. The movement is provided with a friction clutch to relieve the entire switch mechanism of injurious strain, should the movement of the switch be obstructed or should the indication current, for any reason, fail to be generated. Movement is imparted to the various switch parts by the motor through a train of gears, the pin E on main gear being directly connected with the lock movement by the rod G and to the switch points by engagement with the cam crank D. It is through the medium of the lock movement H that the lock plunger, detector bar and pole changer are operated. Simultaneous movement is transmitted from the crank R to the lock plunger through link S, and to the detector bar through link T. It will be seen that a train occupying the track, in preventing the initial movement of the detector bar, would make impossible the withdrawal of the lock plunger and the consequent movement of the switch points. Motion is imparted to the pole changer C through the medium of the pole changer movement I by the last ⅛-in. movement of the lock

M^4-M^4. The circuit breaker CB^4 (Fig. 1767 and 1768) is arranged to cut current off from these magnets whenever the switch is in its full normal or full reverse position. Figs. 1774-1775 show gear frame together with the stock rails securely bolted and braced to a tie plate O, by this means rigidly

Fig. 1793. Installation of Model 2 Switch Machine, Mayfair, Ill., C. & N. W. Ry.

maintaining all of their parts in their proper relation to each other. The lock, front and throw rods are shown in Figs. 1774-1775 at M, N and P, respectively.

Fig. 1796 illustrates an arrangement for throwing one de-

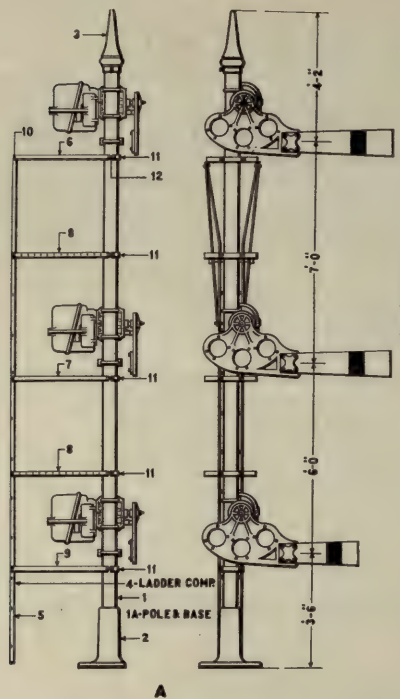


Fig. 1794. Assembly of Model "2A" Interlocking Bridge or Bracket Signal.

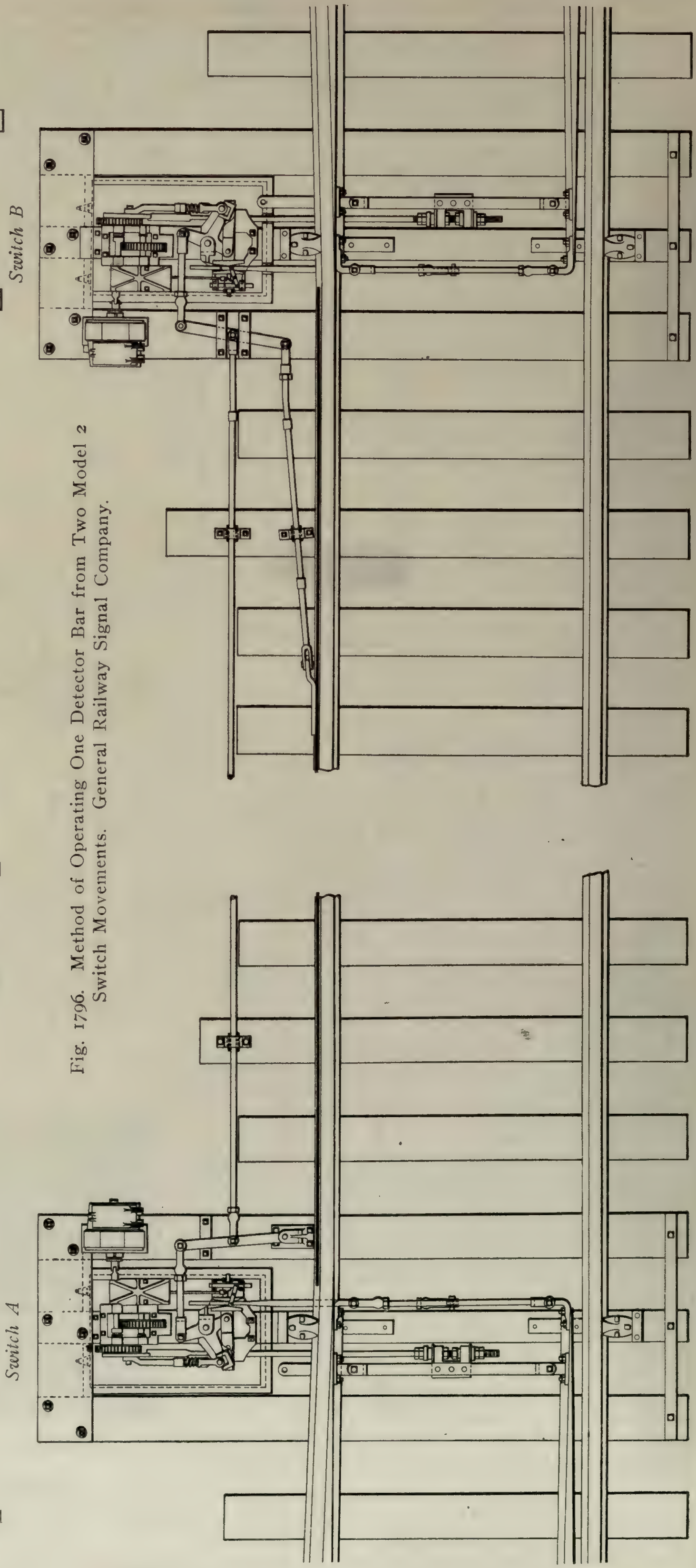


Fig. 1796. Method of Operating One Detector Bar from Two Model 2 Switch Movements. General Railway Signal Company.

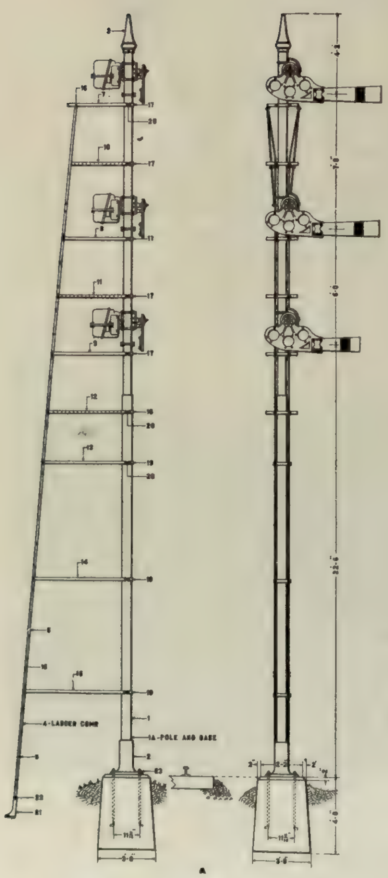


Fig. 1795. Assembly of Model "2A" Interlocking Ground Signal.

tector bar from either of two switch movements. The device consists of a floating lever at B, centrally connected to a pivoted lever at A. The upper extremity of each lever is connected to the lock crank of its respective switch movement. The lower end of the lever at A is pivoted as shown, and that of the lever at B is connected to the detector bar. If the upper end of the lever at B be moved to the left, the lever will move about its center as an axis and the bar will be moved. In this case the center of the lever is held stationary by the rod and the lever at A. If the lever at A be

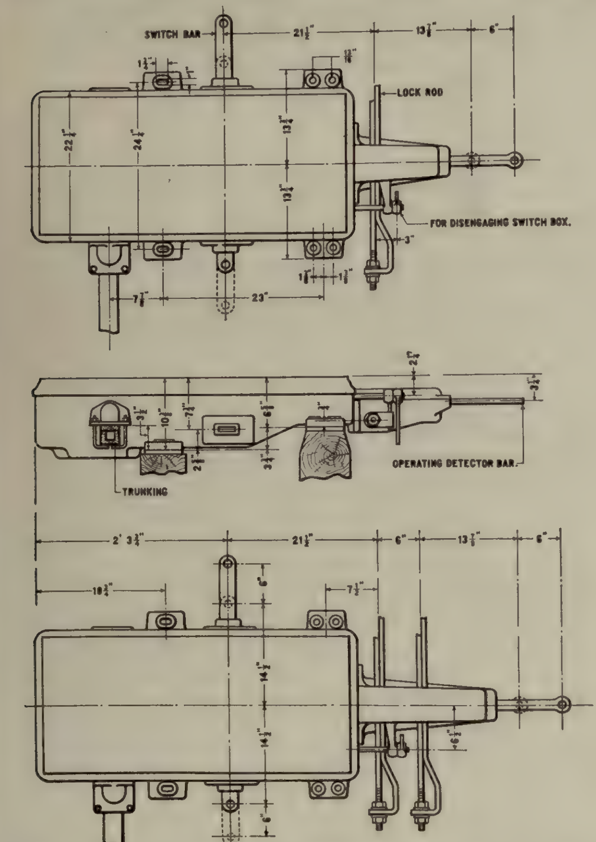


Fig. 1797. Outline and Dimensions of Model 4 Switch Machine.

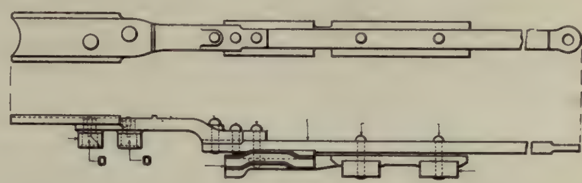


Fig. 1800. Locking Bar—Model 4 Switch Machine.

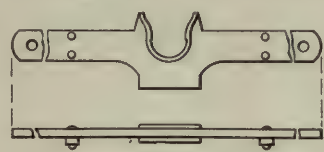
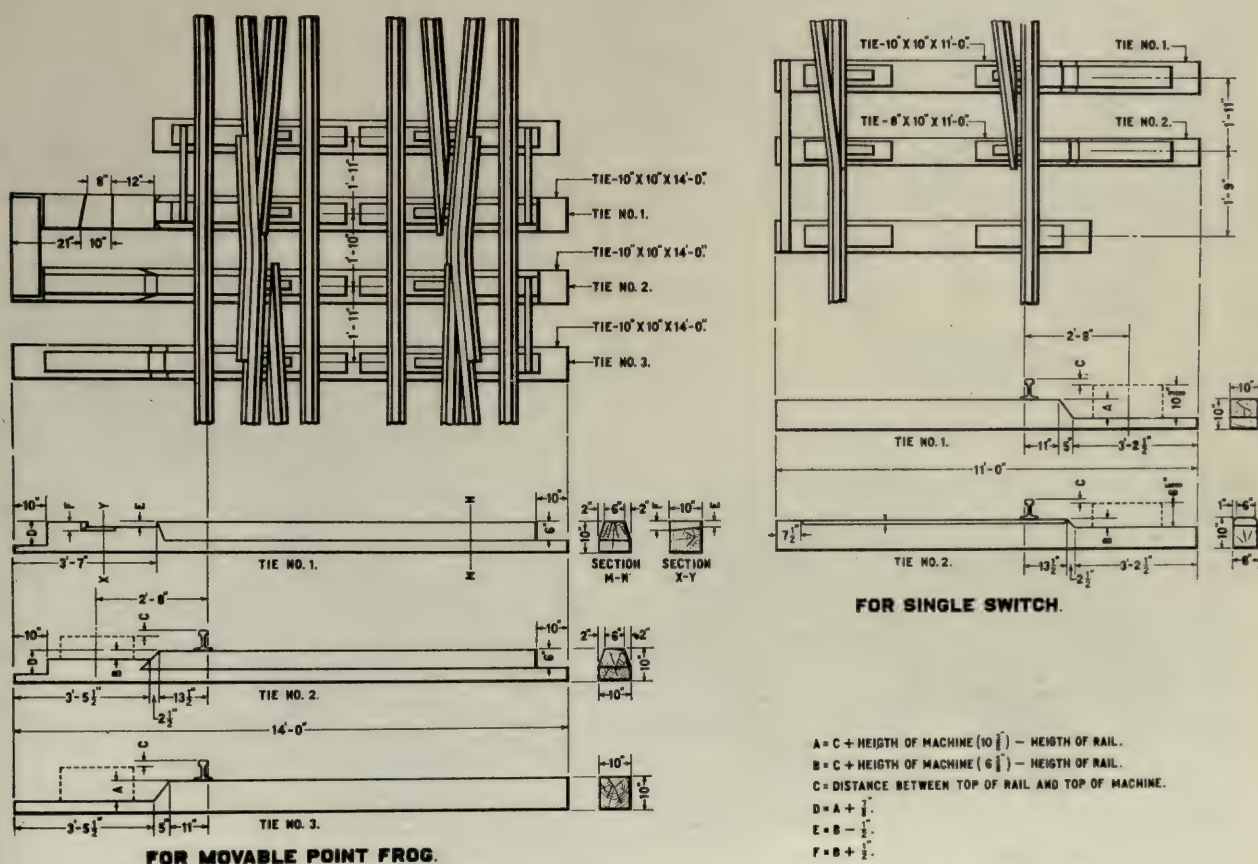
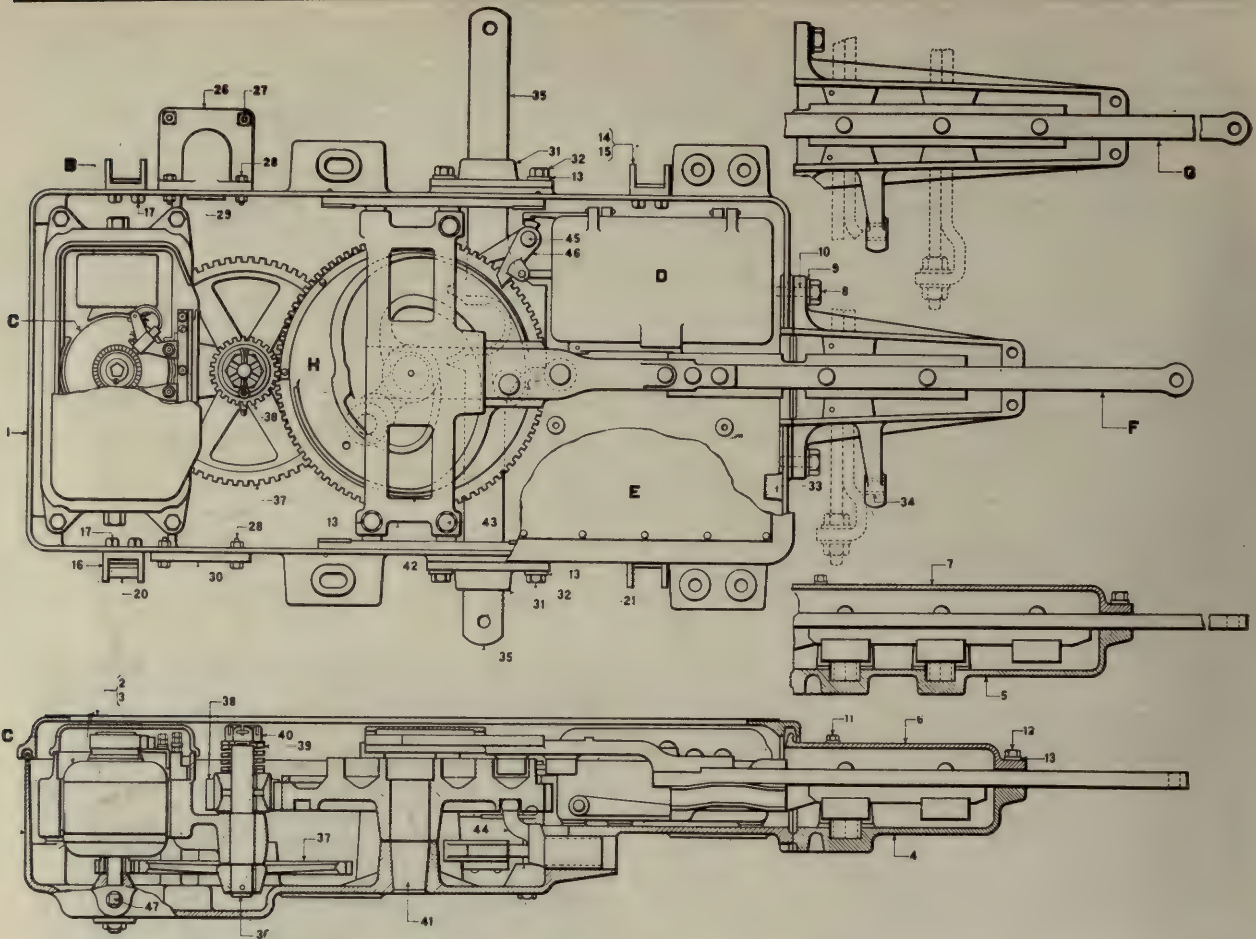


Fig. 1801. Throw Rod—Model 4 Switch Machine.

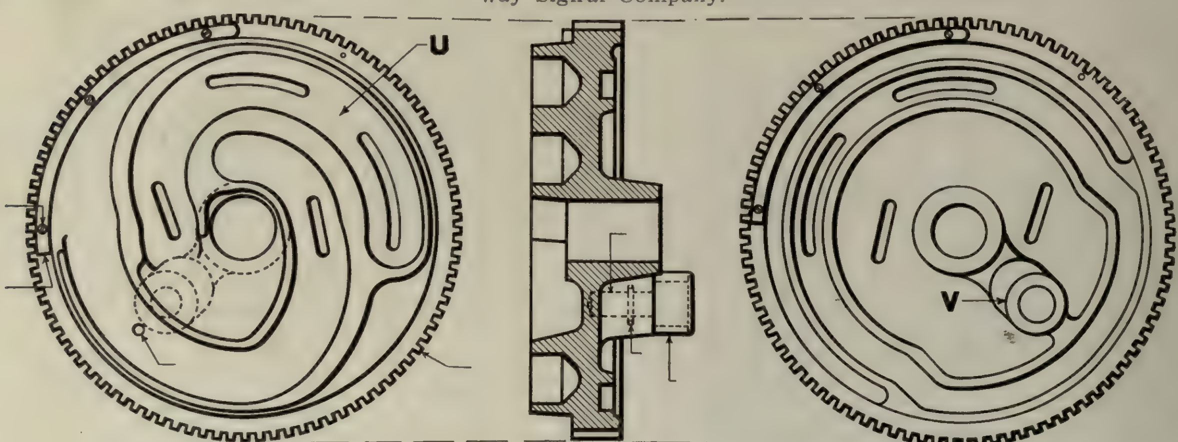
Fig. 1802. Installation of Model 4 Switch Machine. Chicago Terminal. C. & N. W. Ry.



Figs. 1798-1799. Framing for Model 4 Switch Machine. General Railway Signal Company.

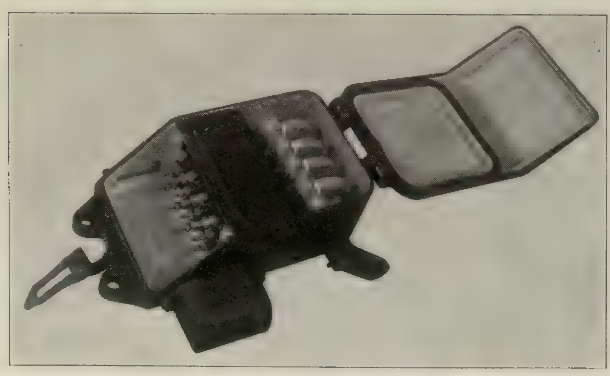


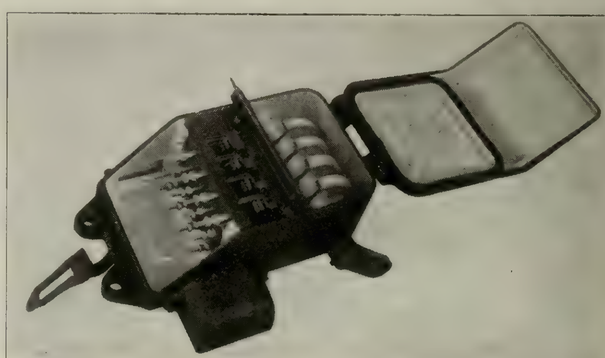
Figs. 1803-1806. Model 4-A Switch Machine. Assembly Single Switch or Movable Point Frog. General Railway Signal Company.



Top View. Section. Bottom View.

Figs. 1807-1809. Main Cam Gear, Model 4 Switch Machine. General Railway Signal Company.





Supplemental Cover Closed. Supplemental Cover Open.

Figs. 1810-1811. Universal Model 5, Form A Switch Box. General Railway Signal Company.

Fig. 1812. Installation Model 4 Switch Machine. New York Central Electric Zone.

moved to the right, it will move the connecting rod, which will transmit motion to the lever at B. This lever will move to the right about its upper end as an axis and the bar will be thrown. These levers are so proportioned that in either of the above cases the bar would be moved through half its full stroke—that is, to the center and back. If both switches should be moved at once, the bar would move through its full stroke and back, since the upper end of the lever at B would be moved to the left at the same time that its center was moved to the right.

Fig. 1813. Installation Model 4 Switch Machine, and Model 2-A Dwarf Signals. Chicago Terminal. C. & N. W. Ry.

The Model 4 switch machine shown in Figs. 1797-1806 inclusive, is designed so that it is suitable for installation where clearances are limited and where it is desired to have all operating parts within one case. All parts are especially designed for being accessible, and the case to afford complete protection against the weather and to be absolutely dust-proof. The case, which is substantially constructed of cast iron, forms a base plate for the mechanism and is bolted through the tie plate to the head block and the next tie back (Figs. 1798-1799). The mechanism can be used as either right or left hand, without change, as it makes no difference to which side the lock and throw rods are connected. One or two adjustable lock rods can be used which permit the use of the machine for the operation of double slip or movable point frogs.

The motor is of the four-pole type, power being applied to the switch points through a train of gears and the cam movement on the main gear, the whole being protected as in the Model 2 switch machine by a friction clutch designed with large surfaces and lined with fiber. Where it is desired to operate the switch other than electrically, by inserting a crank into a hole in the end of the armature shaft it is possible to turn the machine through the whole or any part of its movement. An internal switch box can be provided, which is so designed as to permit the closing of its contacts only when the switch points have been moved to and locked in their proper position. To insure that, on the completion of any movement, both switch points and machine lie in their proper relative position, the lock rod is provided with separate dogs for locking the lock bar in the normal and reverse positions, respectively, these dogs having such relative position to the lock rod that the normal dog may not enter the notch in the lock bar when the switch is in the reverse position and vice versa. Fig. 1803 shows view of the motor, friction clutch, main gear, pole changer and mechanical circuit controller assembled within the case. Fig. 1800 shows the locking bar, Fig. 1801 the throw rod, and Figs. 1807-1809 top, sectional, and bottom views, respectively, of the main cam gear.

The intermittent movement in the locking bar is accomplished by the rollers O-O on the locking bar (Fig. 1800) engaging with the cam U on the upper side of the main gear (Fig. 1807). The

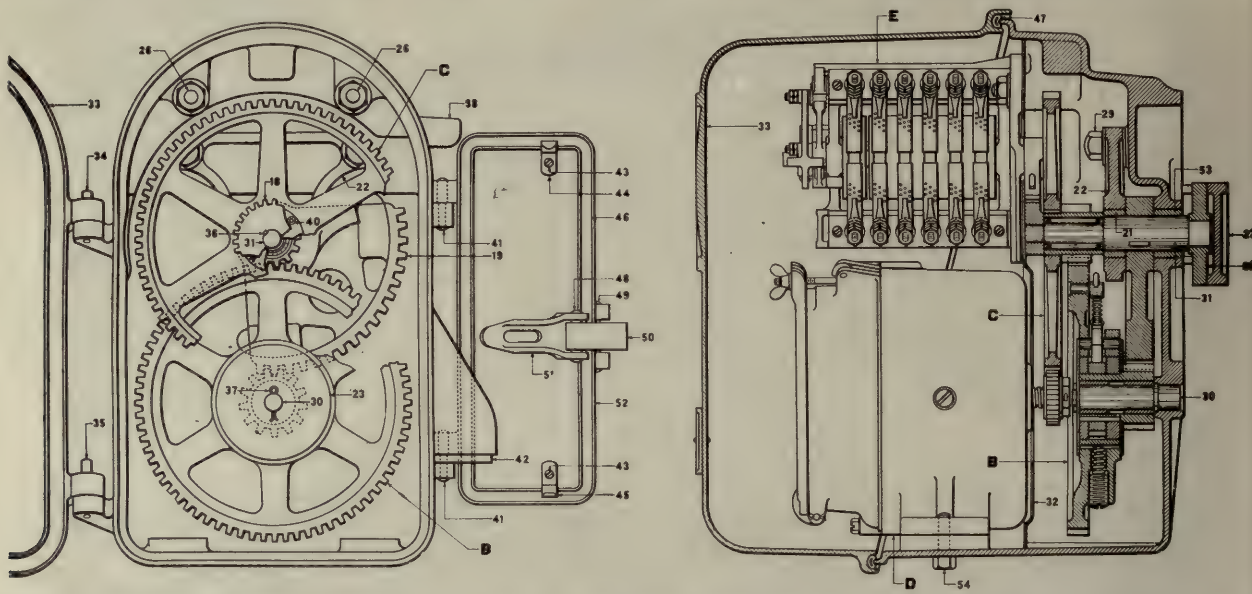
switch points are thrown by the roller V on the lower side of the main cam gear (Fig. 1809) engaging a jaw in the throw rod (Fig. 1801).

The cycle of operation of the Model 4 switch machine is essentially the same as in the Model 2, with the exception that a 90-deg. free run of the main cam gear is added at the start and finish of the movement, thus allowing the motor to speed up, after the switch movement has been completed, for the purpose of generating sufficient E. M. F. to furnish a strong and positive indication. The circuit control of the switch machine is identical with that of the Model 2, the description on pages 214-215 therefore being applicable in every particular.

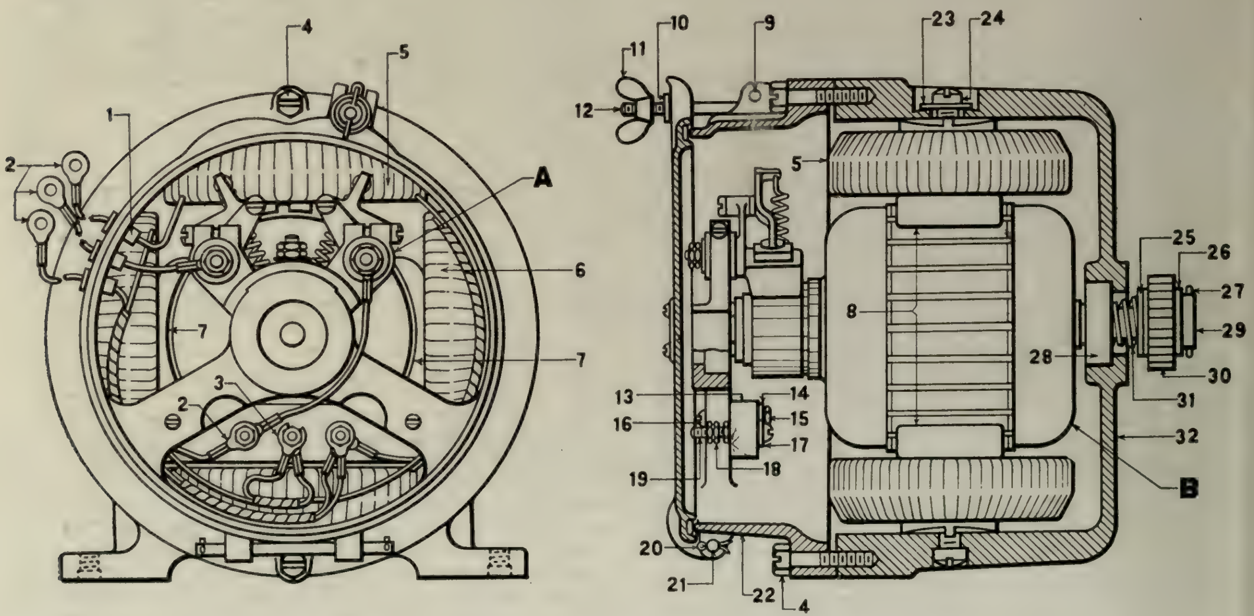
Figs. 1814-1815 show Model 2A, 110-volt dynamic indication signal, the circuits for which were described in connection with Fig. 1767. The signal is clamped to the mast by means of a clamp bearing, which enables the signal to be mounted anywhere on new or existing poles, or any number on a given pole. To insure proper alignment, the driving and semaphore shafts are connected by a coupling which lends itself to a simple means of locking the semaphore in the normal position, thereby preventing improper operation of the signal by any outside agency.

The motor is directly connected to the semaphore shaft through low reduction gearing, so that the armature revolves in either direction with the semaphore shaft. The motor, in addition to operating the signal, is of such design that it will also hold the signal in the proceed positions without the intervention of the ordinary forms of electro-mechanical slot or other retaining devices. When the signal has assumed the desired position for the proceed indication, high-resistance field windings are thrown in series with the operating fields and the armature is magnetically locked in that position. No mechanical contact of any kind exists between the moving and stationary parts of this motor. Due to the fact that the motor is driven backwards by the mechanism gearing when the signal blade is returning to the stop position, electric means may be used for stopping the movement of the signal blade without the use of the dash-pot or other additional mechanical contrivances. This is accomplished in the last few degrees' movement of the mechanism by the generation of the current necessary to tripping the indication mechanism on the controlling lever.

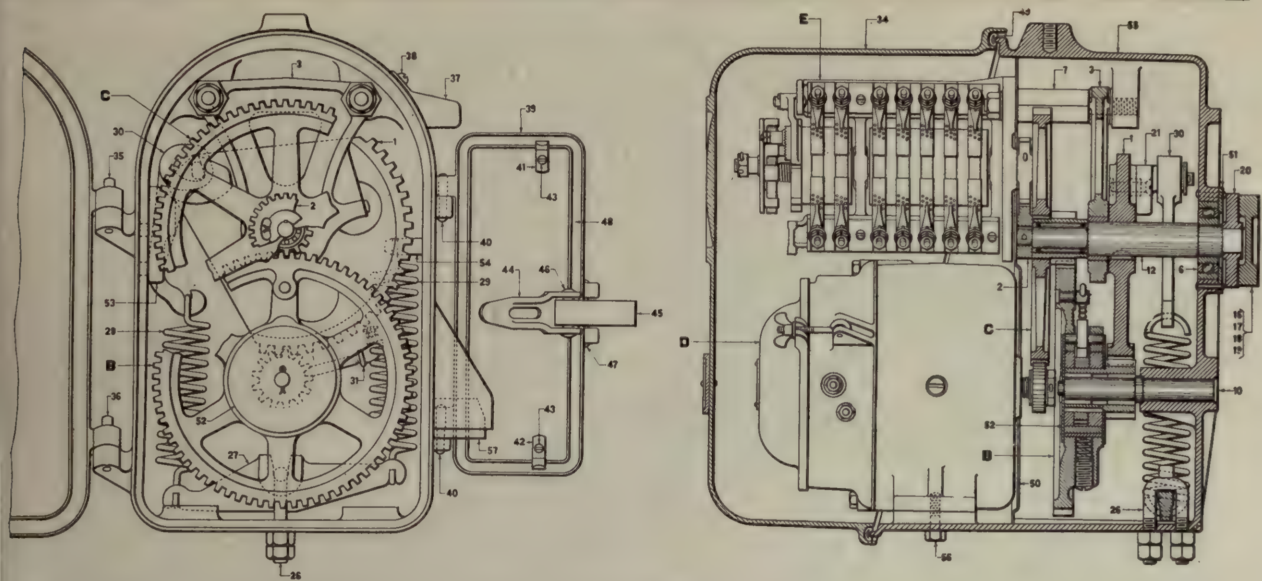
The circuit breaker is a complete unit connected to the main operating shaft by means of a segmental gear. The commu-



Figs. 1814-1815. Universal Model "2-A" Direct Connected Signal Mechanism. 110 Volt D. C. Non-Automatic Control Dynamic Indication. General Railway Signal Company.



Figs. 1816-1817. Motor for 110 V. D. C. Model "2-A" Signal.



Figs. 1818-1819. Universal Model "2A" Direct Connected Signal Mechanism. 110 Volt D. C. Semi-Automatic Control—Dynamic Indication. General Railway Signal Company.

Fig. 1820. Model "2A" Interlocking Signal. S. P. & S. R. R.

Fig. 1821. View Showing Lake Street Interlocking Plant. Chicago Terminal. C. & N. W. Ry.

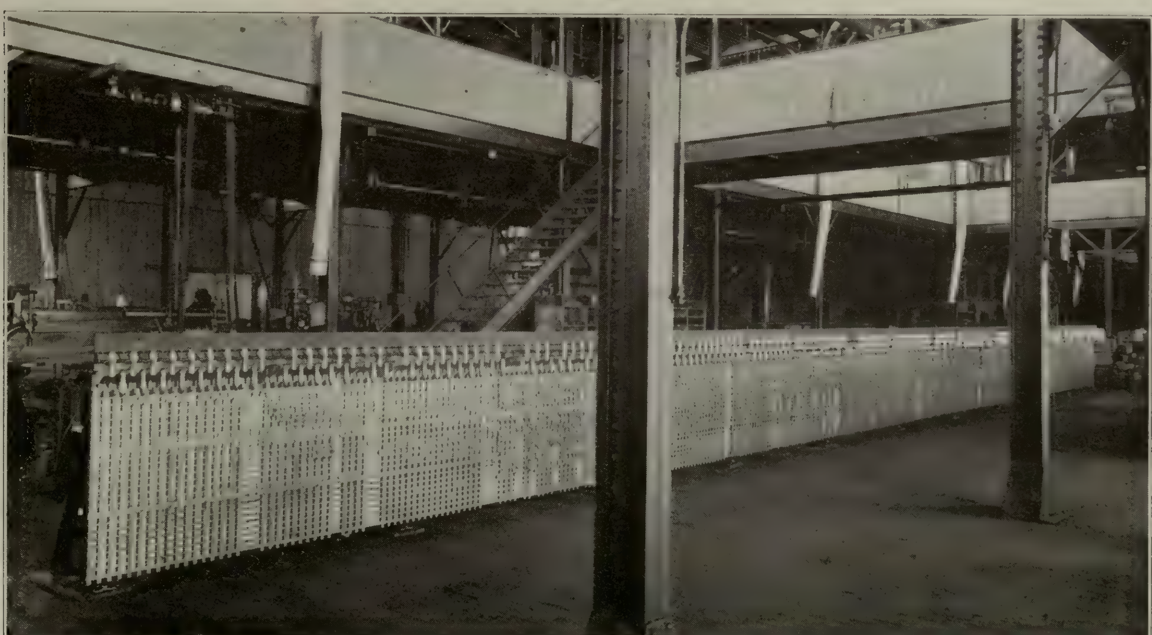


Fig. 1822. Unit Type Lever Interlocking Machine (400 Levers) Grand Central Terminal—N. Y. C. & H. R. R. R. General Railway Signal Company.

Fig. 1823. Rear View of Unit Type Lever Interlocking Machine (360 Levers). Grand Central Terminal. N. Y. C. & H. R. R. R.

tator is capable of being equipped with 14 circuits, including those for the local control of the signal, and such contacts which are used to break the operating current of the signal proper are arranged to "snap" over, a quick break being essential.

In the semi-automatic Model 2A signal, the initial free movement of the mechanism is accomplished by having one shoulder of the coupling so cut away that the 40-deg. rotation of the driving shaft is necessary before it will engage with the semaphore shaft. Fig. 1819 shows the movement by which the springs are put under tension, the two coil springs being connected to the driving shaft by an equalizer and crank, one end of the latter being fastened to the main sector on the driving shaft. The construction is such that the backward tension of the spring is neutralized after the blade has moved a few degrees from the stop position, so that the springs are in no way depended upon for the restoration of the blade to normal. With the exception of this feature, the semi-automatic signal is the same as the regular signal, the design of its mechanism, therefore, not requiring further discussion.

Fig. 1824. Unit Type Lever Interlocking Machine (360 Levers). Grand Central Terminal. N. Y. C. & H. R. R. R. General Railway Signal Company.

Fig. 1825. Unit Type of Lever Interlocking Machine (360 Levers). Grand Central Terminal. N. Y. C. & H. R. R. R.

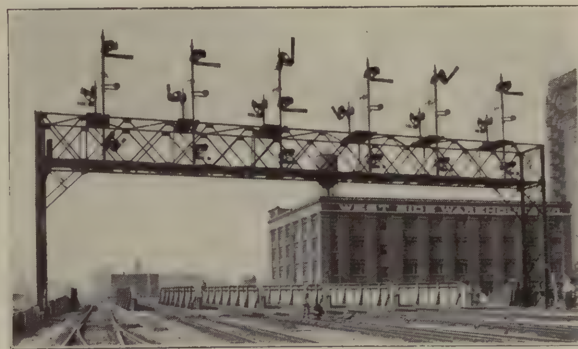
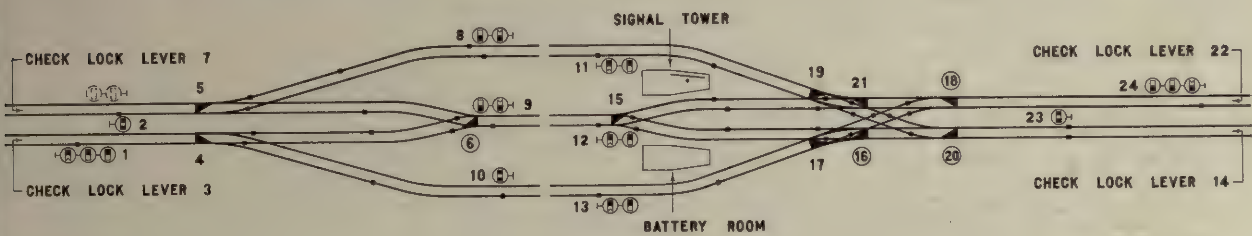


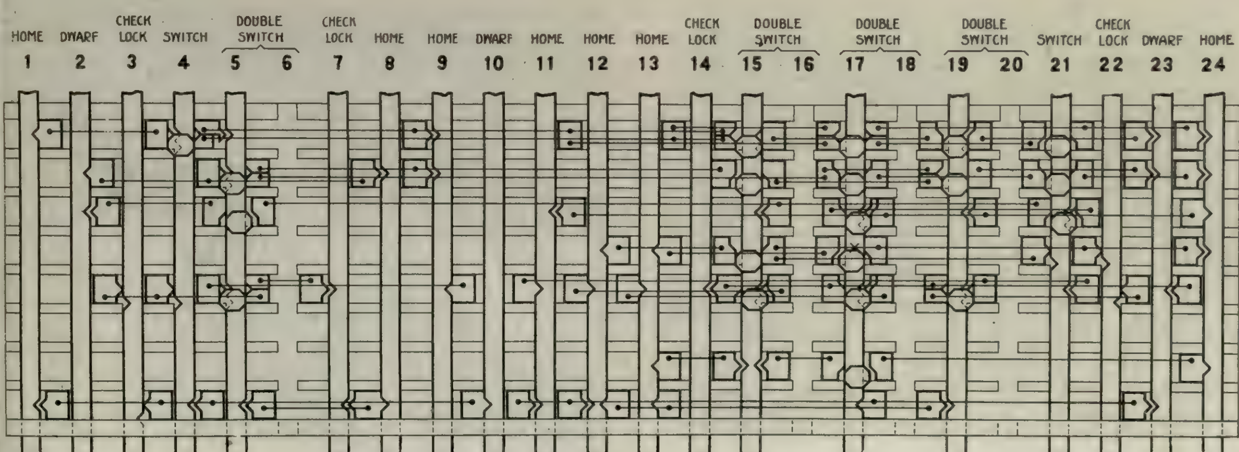
Fig. 1826. Model "2A" Signals—Bridge A. Chicago Terminal, C. & N. W. Ry.



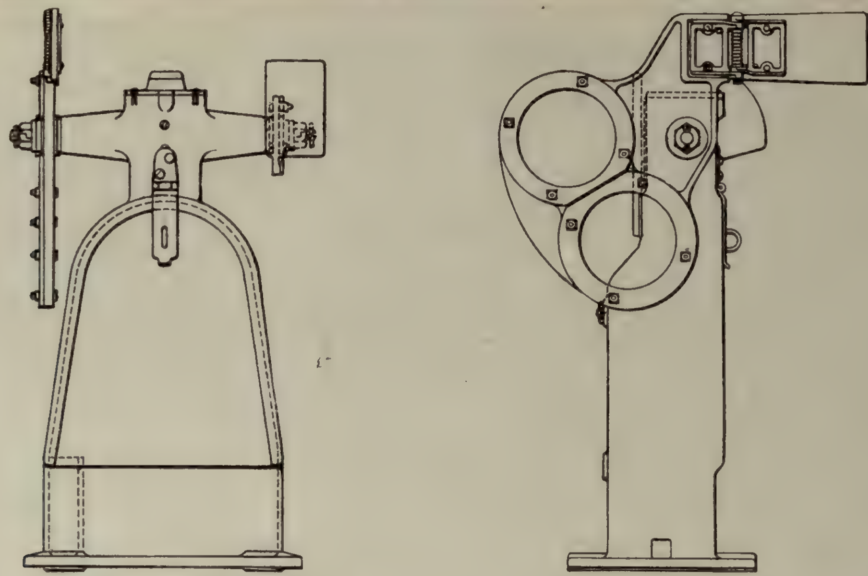
Track Plan.

LEVER	WHEN	LOCKS
1		4—(4)—10
	4—15—19	23
	4—(17)	24
	(4)	9—5
	(4)—(21)—17	24
	(4)—(15)—19	23
2		5—(5)—8
	5—21—17	24
	5—(19)	23
	(5)	9
	(5)—(21)—17	24
	(5)—(15)—19	23
3		
4		
5		
6		
7		
8		7—5
9		5—(5)
	5	(4)—(3)
	(5)	7
10		(3)—4
11		19—(19)—21—24—17
	19	(22)
	(19)	23—14
12		15—(15)—17—19
	15	(21)—24—(22)
	(15)	23—14
13		17—(17)—15—19
	17	23—14
	(17)	(22)—24
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		19—(19)—17
	19	15—(15)
24		17—(17)—19
	17	21—(21)
	17(21)—	15
	(17)	15

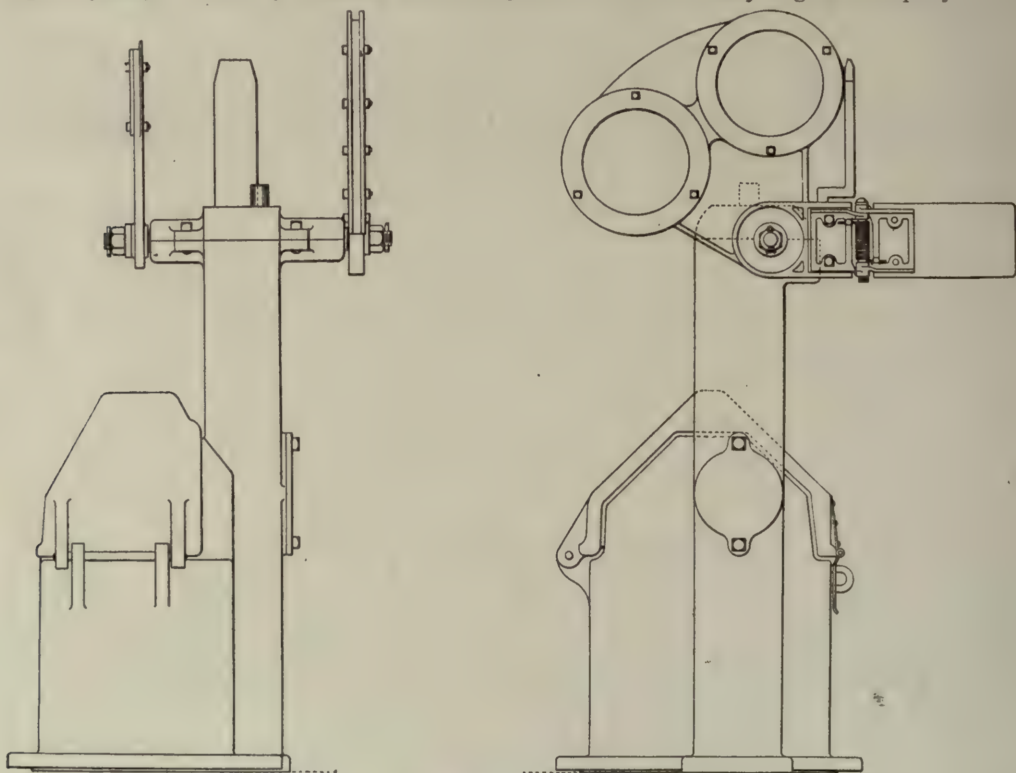
Locking Sheet.



Figs. 1827-1829. Track Plan, Locking Sheets and Dog Chart. Hudson & Manhattan Railroad Terminal. Model 2 Electric Interlocking Machine. General Railway Signal Company.



Figs. 1830-1831. Model 3 Solenoid Dwarf Signal. General Railway Signal Company.



Figs. 1832-1833. Model 2 Solenoid Dwarf Signal. General Railway Signal Company.

Fig. 1834. Model "2A" Dwarf Signal. Chicago Terminal, C. & N. W. Ry.

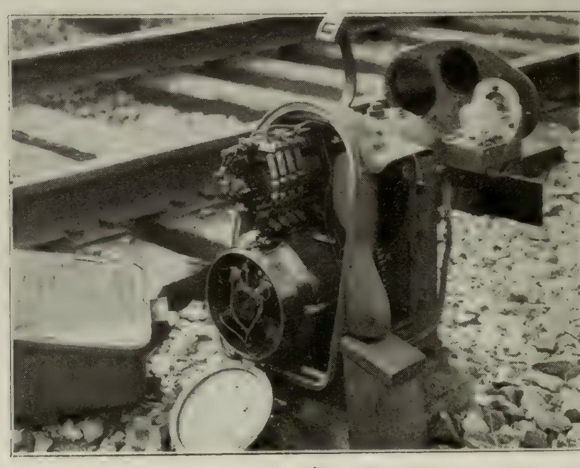
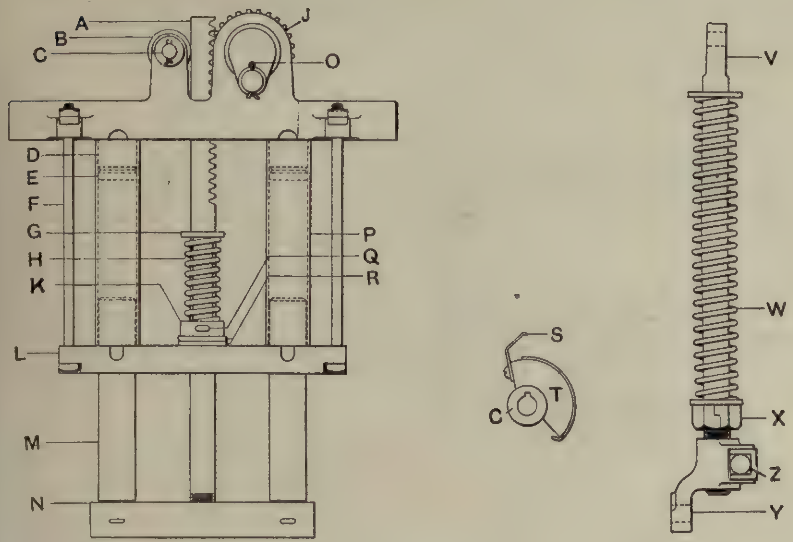


Fig. 1835. Model "2A" Dwarf Signal. New York Central Electric Zone.



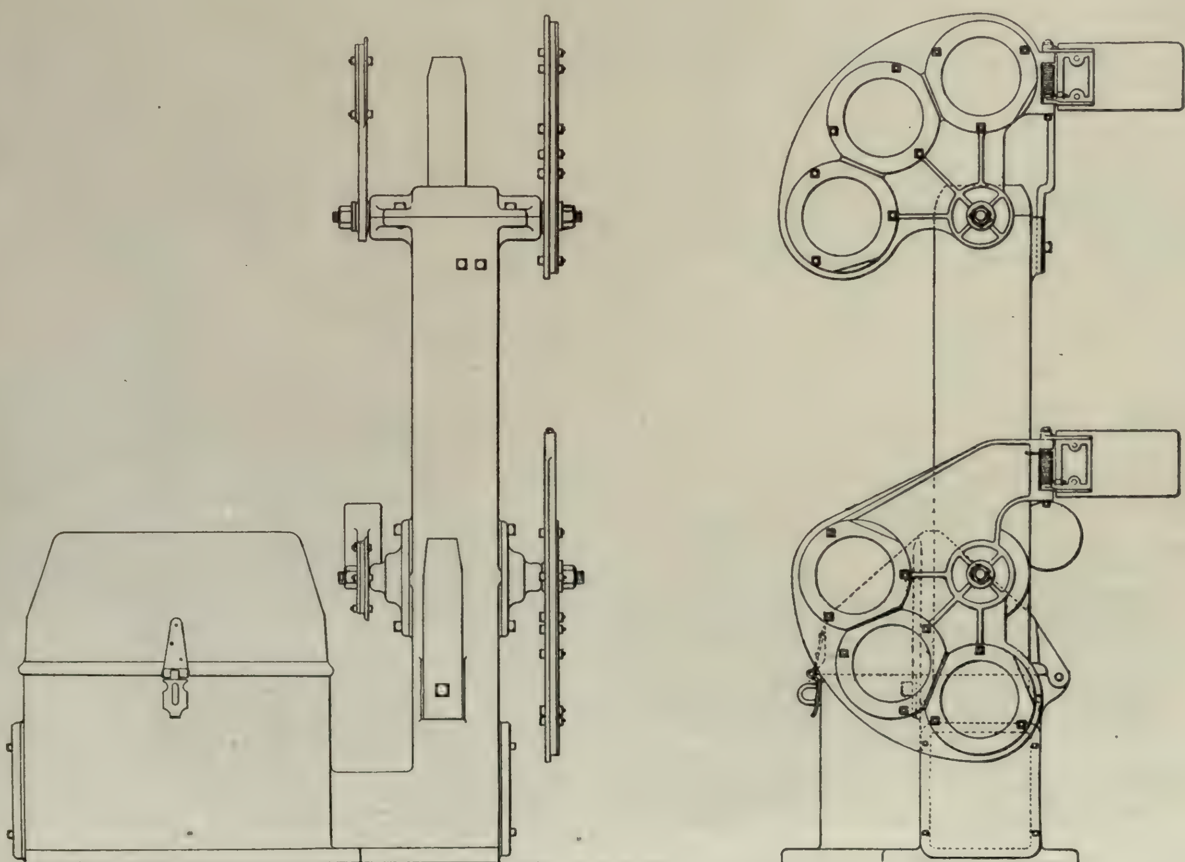
Names of Parts of Model 2, Electric Dwarf Signal. Figs. 1836-1838.

A *Rack*
B *Roller*
C *Shaft for* **B**
D *Magnet Core, Brass*
E *Cap for* **D**
F *Bolt*
G *Washer*

Figs. 1836-1838. Details of Solenoid Dwarf Signals, Figs. 1830-1833.

(O Is Normally off Center, Locking the Signal in the Stop Position.)

H *Restoring Spring*
I *Commutator, Indication*
J *Pinion*
K *Collar*
L *Bottom Support for* **H**
M *Armature*
N *Yoke*
O *Crank*
P *Tube, Brass*
Q *Cotter*
R *Washer*
S *Contact*
T *Insulating Segment*
V *Operating Rod*
W *Spring*
X *Elastic Nut*
Y *Eye*
Z *Clamp Screw*

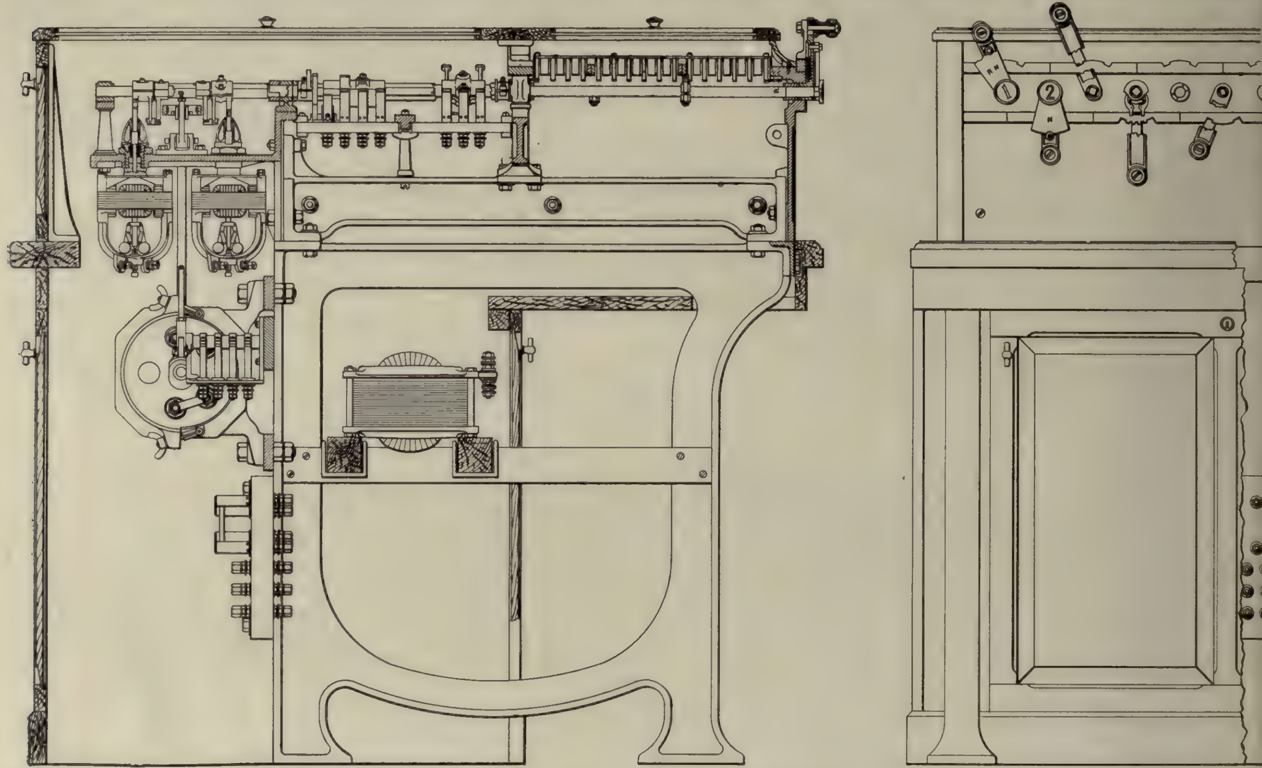


Figs. 1839-1840. Model 2 Solenoid Dwarf Signal. General Railway Signal Company.

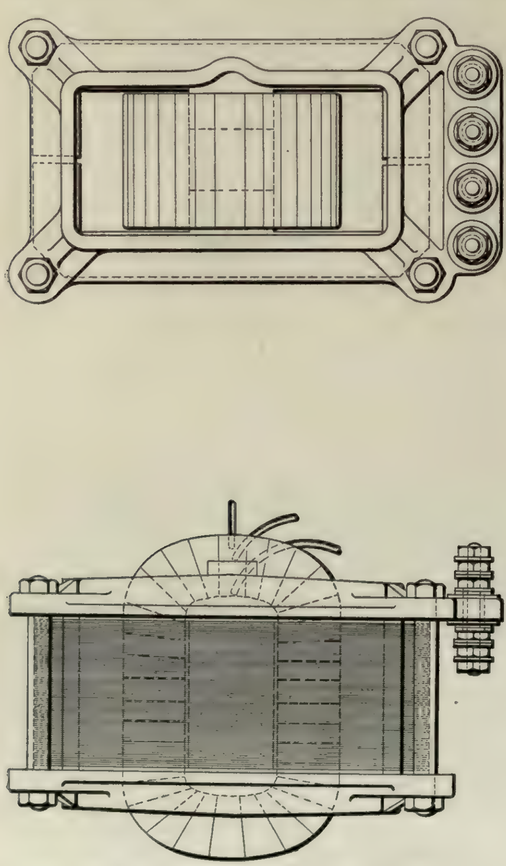
THE UNION SWITCH & SIGNAL COMPANY.

The interlocking machine, an end and a front elevation of which are shown in Figs. 1841-1842, and a rear view in Fig. 1851, resembles very much in general appearance the electro-pneumatic machine, Fig. 1955, and the levers have the same movements. The preliminary movement, limited by the indication latch, effects the locking of all levers whose movements would conflict with the new position of the lever. The final movement, which can take place only after the indication is received, unlocks all levers whose movements would not conflict with that position of the lever. The preliminary movements, in reverse directions, overlap to such an extent as to permit a range of movement sufficient to throw the electric controlling switch from one controlling position to the other at the will of the operator.

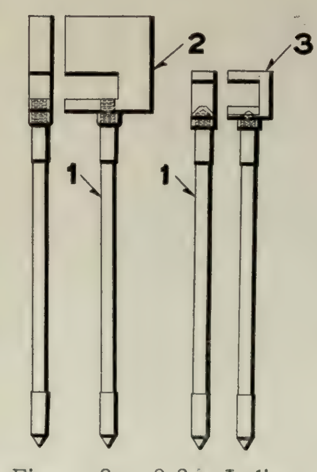
The switch points are made to follow the movements of the lever by sending a current through one or the other of two independent series of field windings on the switch operating



Figs. 1841-1842. Electric Interlocking Machine; Views Showing Elevation in Section and Front Elevation.

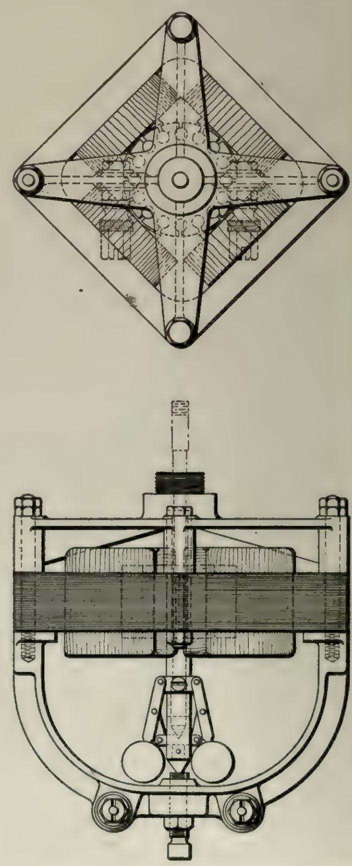


Figs. 1843-1844. Indication Transformer.



Figs. 1845-1848. Indication Latches.

1 *Stem*
2 *Latch for Switch Lever*
3 *Latch for Signal Lever*



Figs. 1849-1850. Indication Motor.

motor, which causes rotations in opposite directions. Each independent switch requires one lever, but any two switches which are to be operated simultaneously, as two switches of a crossover, have but one lever.

The signal levers stand normally in the middle position and are moved to the right or left for the purpose of operating opposing signals. Two or more signals, governing diverging routes, are also controlled by one lever when the signals are those operated by one motor, as for instance, when two or three arms are placed on one post. The selection between the arms in this latter case is effected by means of selectors, operated by the switch points themselves, or by the levers which control the movements of the points.

While in the accompanying illustrations the interlocking machine is shown equipped with a stroke completing attachment, it is not customary to apply this device. The stroke completing apparatus comprises a swinging arm, loosely pivoted to each lever shaft, and pawls carried by the frames of the indication segments for engaging these arms. The arms are all connected by means of a bar extending the full length of the machine, and are made to oscillate by means of a motor connected to the bar through an eccentric. When an indication is received, the indication latch lifts a pawl into engagement with one of the swinging arms and the lever is thereby rotated through the final part of its movement. The circuit to the motor is controlled by a relay, the exciting coil of which is placed in the

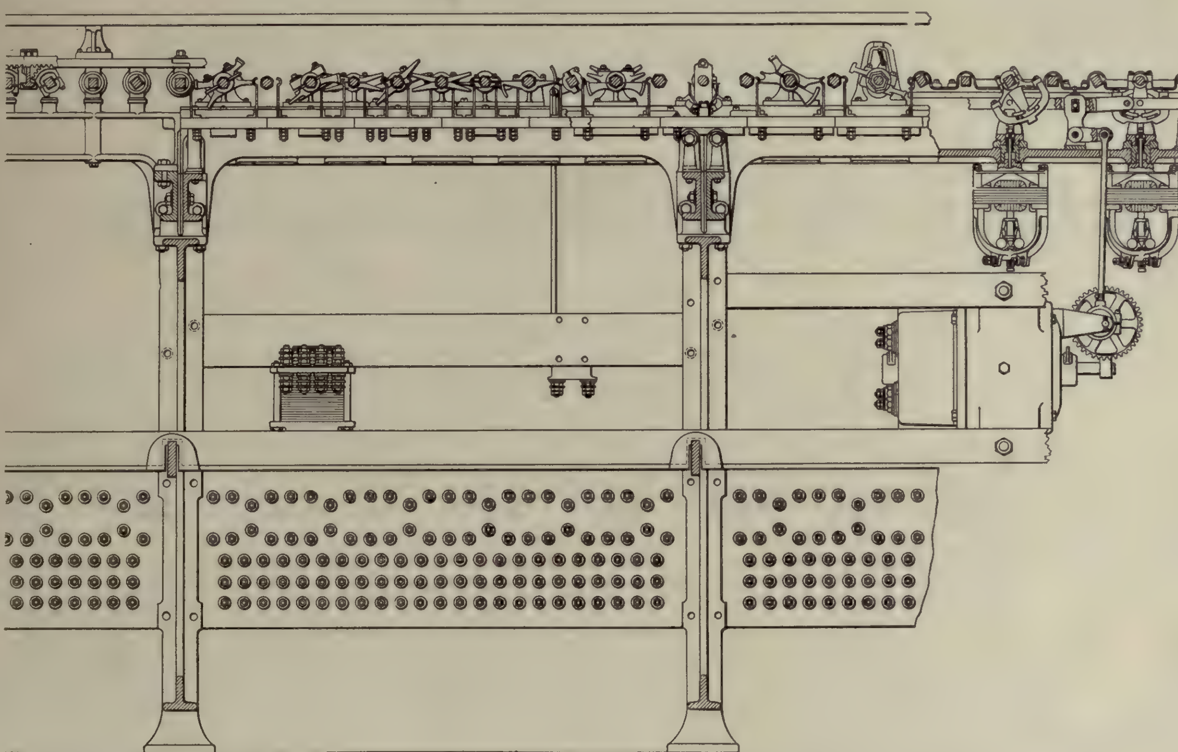
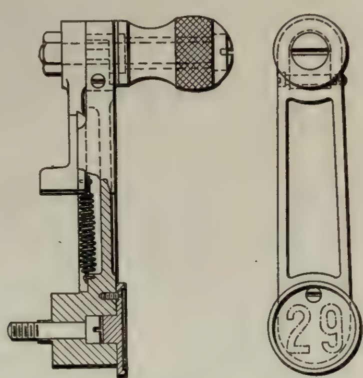
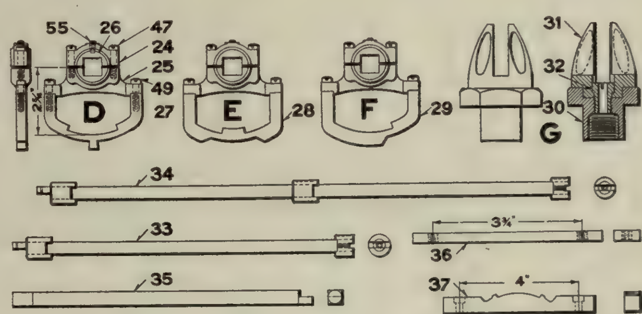
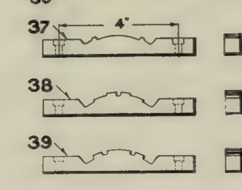


Fig. 1851. Electric Interlocking Machine, View Showing Back Elevation Partly in Section.



Figs. 1852-1853. Detail of Lever.





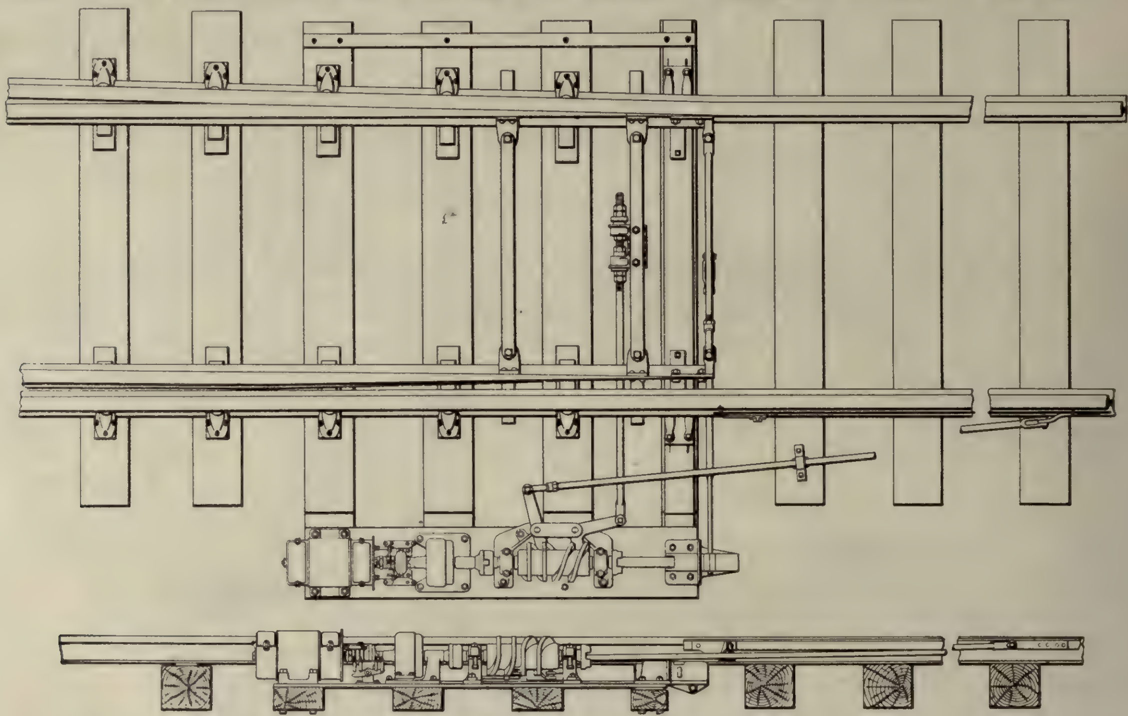
Figs. 1854-1873. Details of Lever Connections, Quadrants, Indication Segments and Guide.

Names of Parts of Figs. 1854-1873.

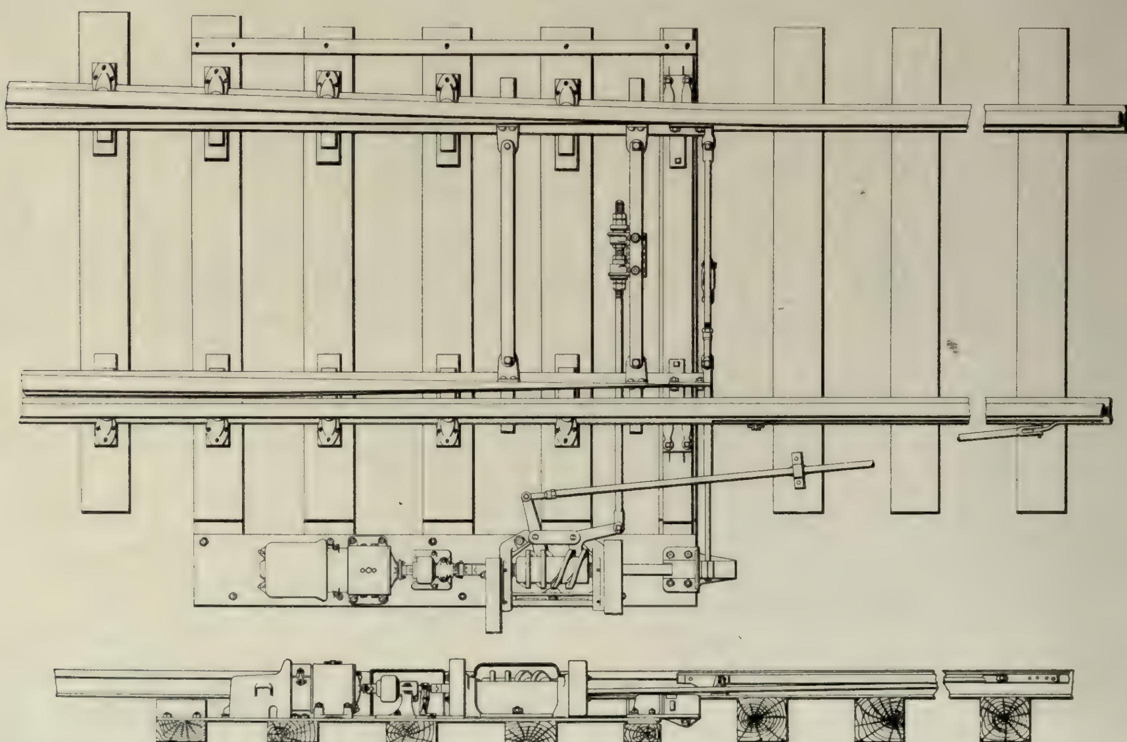
D *Indication Segment for Switch Lever*
E *Indication Segment for Two-Position Signal Lever*
F *Indication Segment for Three-Position Signal Lever*
G *Guide for Indication Latch and Segment*
24 *Clamp, Upper Half*
25 *Clamp, Lower Half*
26 *Journal for Clamp*
27 *Segment for Switch Lever*
28 *Segment for Two-Position Signal-Lever*
29 *Segment for Three-Position Signal Lever*
30 *Guide Base*
31 *Bushing*
32 *Jaw*
33 *Long Lever Shaft*
34 *Short Lever Shafts (2 coupled)*
35 *Indication Segment Shaft*
36 *Strip to Support Slate Base for Circuit Controller*
37 *Quadrant for Switch Lever.*
38 *Quadrant for Two-Position Signal Lever*
39 *Quadrant for Three-Position Signal Lever*
47 *Machine Screw*
49 *Machine Screw*
55 *Set Screw*

main lead between the battery and the machine. Controlled in this way the motor is only in action when required for completing the stroke of a lever.

The indication part of the system is worked in the following manner: The commutator of the motor, in addition to the parts usually found on a direct-current motor, is provided with the varying position of the segment to which the collector ring is attached. This undulating current induces an alternating current in the secondary of a transformer, Figs. 1843-1844, and this alternating current drives a small induction motor, Figs. 1849-1850, which releases the indication latch and permits the completion of the stroke of the lever on the ma-



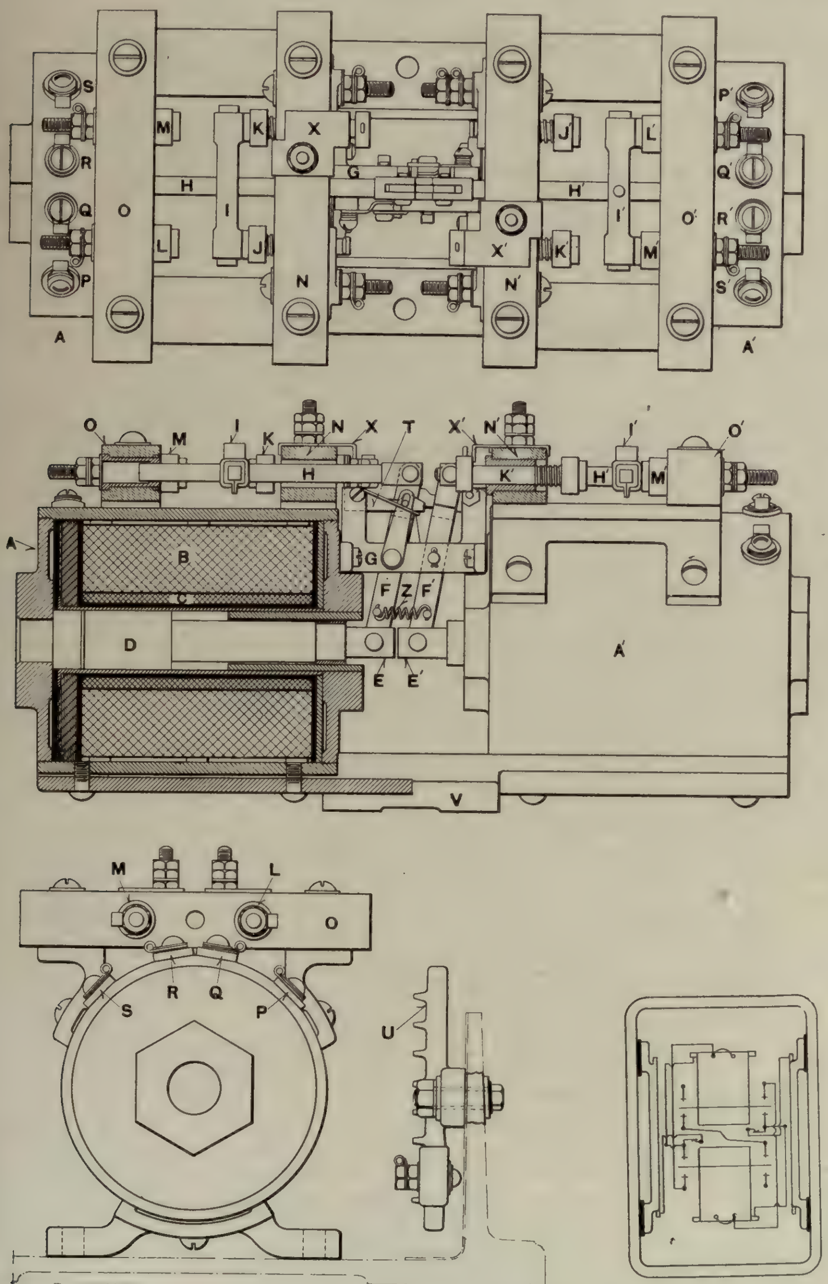
Figs. 1874-1875. Electric Switch and Lock Movement with Electric Clutch and Planetary Reduction Gear; Views Showing Plan and Side Elevation.



Figs. 1876-1877. Electric Switch and Lock Movement with Countershaft Reduction Gear and Mechanical Clutch.

a collector ring and a brush, bearing thereon. The collector ring is connected electrically with one segment of the commutator. At the end of the movement, the automatic controller changes the path of the current from the operating brush, bearing on the commutator, to the indication brush, bearing on the collector ring, at the same time cutting out the magnetic clutch. The motor then continues to run light, driven by current from the battery, which current is caused to undulate by chine. In this manner the indication is brought about by utilizing the battery current which is transformed into an alternating current. The indication motor previously referred to has its armature shaft in a vertical position; to this is attached a piece of centrifugal apparatus very similar in construction to the well known form of governor used on the steam engine. The rapid rotation of the armature causes the weights to separate, and through a combination of levers, to lift the

indication latch and release the lever. This mode of construction makes it necessary to have a rapid rotation of the indication motor armature to produce the desired effect, and this rotation can be secured only by a rapid succession of alternating impulses in the coils of the motor. A direct current through these coils has no effect other than to hold the armature against rotation. Single impulses which may be caused by making or breaking a circuit, will cause the armature to move through not more than ten degrees, and a succession of these working the lock rod and detector bar, and the other the switch, connection being made to the detector bar and switch through cranks. The lock is worked direct by a straight bar which slides longitudinally beneath the cam, motion being imparted by means of a lug fitting the cam slot. In each case the cam slot, for a portion of its travel, moves in a plane at right angles to the shaft, so that while that portion is passing the lug on the driving bar or crank, no movement of the latter takes place ; it is only while the lug is engaged by the diagonal portion



Names of Parts of Solenoid Circuit Controller; Figs. 1878-1881.

- A *Solenoid*
- B *High Resistance Coil*
- C *Low Resistance Coil*
- D *Core*
- E *Jaw*
- F *Lever*
- G *Lever Support*
- H *Contact Operating Rod*
- I *Contact Bridge*
- J *Contact*
- K *Contact*
- L *Contact*
- M *Contact*
- N *Slate Block*
- O *Slate Block*
- P *Terminal Binding Screws*
- Q *Terminal Binding Screws*
- R *Terminal Binding Screws*
- S *Terminal Binding Screws*
- T *Latch*
- U *Porcelain Resistance Grid*
- V *Base*
- X *Contact*
- Z *Connecting Spring*

Figs. 1878-1881. Solenoid Safety Circuit Controller for Switch Movement, Views Showing Plan, Elevation and Wiring Diagram.

such impulses, following each other as rapidly as it is possible to make and break a circuit by hand, will cause only a step by step movement of the armature, the armature coming to a full stop at the end of each step, so that impulses produced in this manner will not cause the weights to move from their position of rest against the armature shaft.

Fig. 1874 is a plan and Fig. 1875 a side elevation, showing a switch and its operating mechanism. The switch and lock movement is driven by a direct current motor of about 1½ h.p., designed to be operated at 110 volts. The shaft of this motor is connected by means of a magnetic clutch to a shaft extension in the same line, working a cam drum, which operates the switch and lock. Intermediate between the magnetic clutch and drum, there is a reduction gearing with a speed ratio of 25 to 1. There are two cams on the drum, one of of this slot, that movement is imparted to the switch or lock mechanisms. The operation is as follows: When the drum is revolved by the motor, the lock rod and detector bar immediately begins to move, and as soon as these have completed part of their stroke, their motion ceases and the movement of the switch begins. After the switch has been moved over against the stock rail, further motion of the lock bar locks the switch and at the same time operates a knife switch which opens the control circuits and closes the indication circuit. The cam drum is reversible, so that the movement can be operated either right or left (the position of the motor and clutch remaining the same) by changing the drum, end for end. The motor, clutch and drum are all attached to a steel base plate. The direction of rotation for reversing the switch is controlled by means of two field windings, one of which is cut out while the other is

in circuit. When the switch is to be thrown in the reverse direction, the lever on the interlocking machine merely changes the connection of the operating circuit to the other field winding.

The magnetic clutch permits of breaking the motor connection with the throwing mechanism at the proper time; and the absence of a rigid connection prevents breaking or straining of the parts if the movement of the switch should become

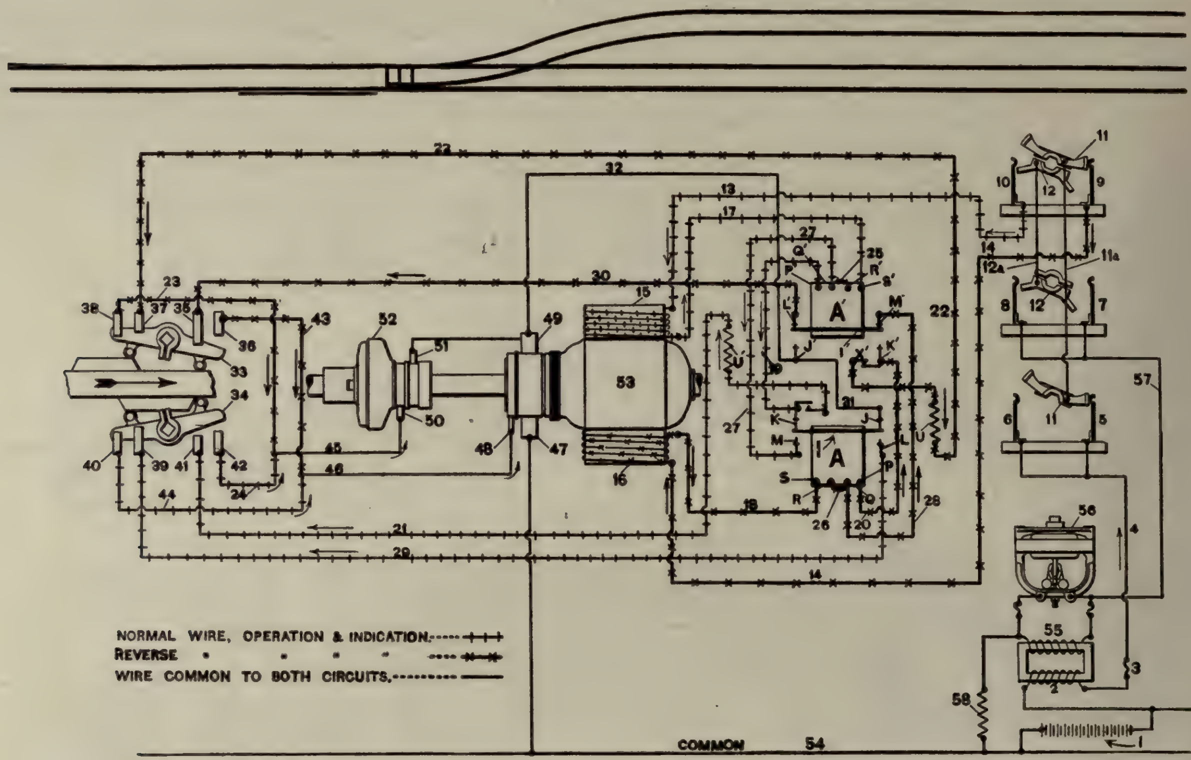


Fig. 1882. Control and Indication Circuits for a Single Switch; Beginning of Reverse Movement.

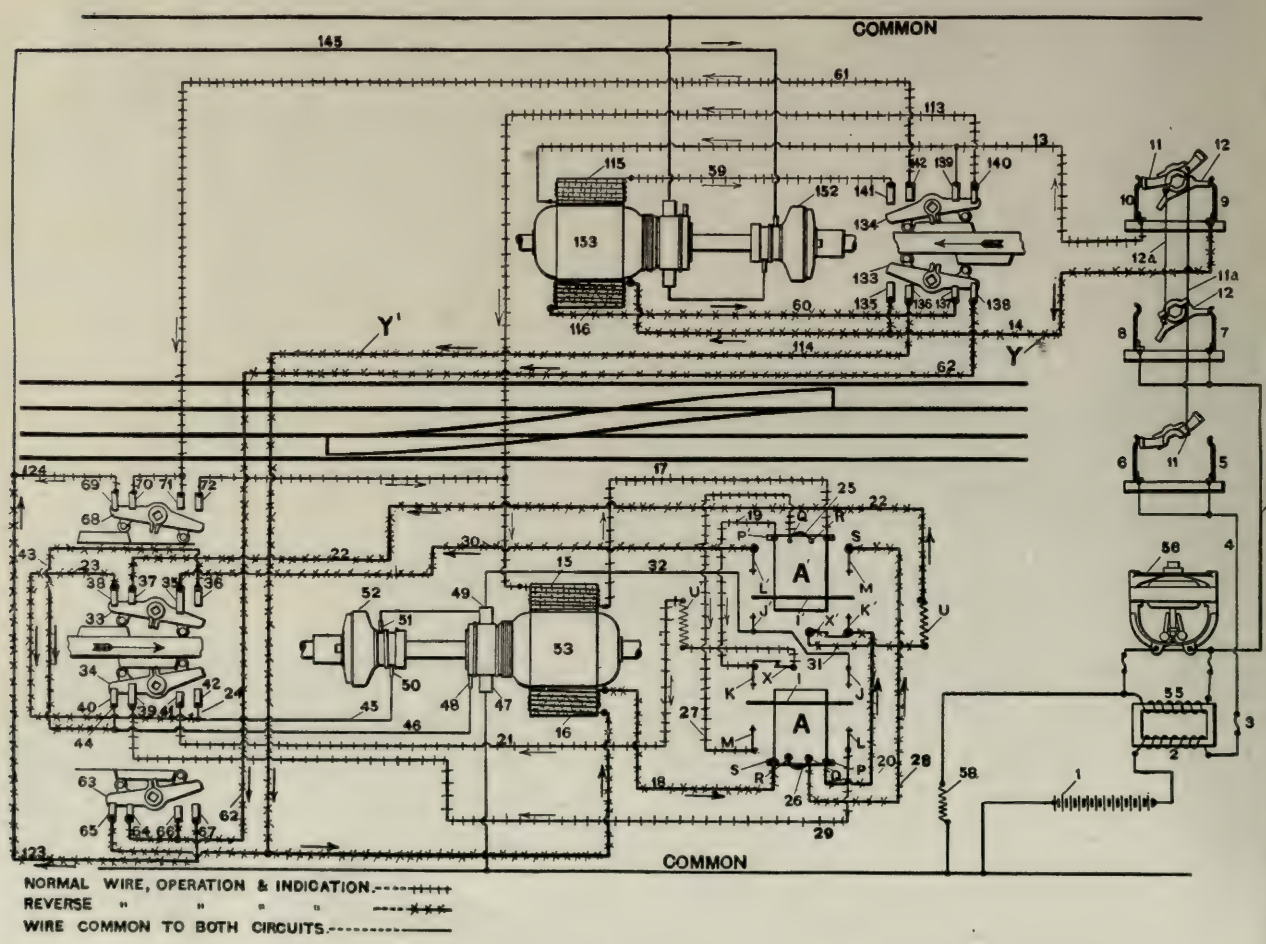


Fig. 1883. Operating Circuits for Crossover; All Parts in Normal Position.

blocked, the blocking of the switch merely causing the clutch to slip until a fuse is blown on the interlocking machine. If the switch is found to be blocked, it can be thrown back by simply reversing the lever, and this can be done quickly enough to avoid blowing the fuse.

Figs. 1876-1877 show this type of switch and lock movement provided with a countershaft reduction gear and also a mechanical clutch instead of the electro-magnetic clutch just described.

The safety controller, which automatically cuts out a switch motor if the wires become improperly connected, combines in one, the functions of two electro-magnetic circuit controllers. The function of one is to open the motor circuit when the lever movement is completed, and of the other to open the next operating circuit when it is energized improperly by connected wires, and thus to prevent a wrong movement. The instrument which is illustrated in Figs. 1878-1881, comprises two solenoids A and A′, fixed to a cast iron base V. Each solenoid has a movable core D, connected by means of a jaw E to a lever F. The lever F is pivoted at its middle to a fixed support G and is connected at its upper end to a rod H, free to move longitudinally. The rod H carries a contact

At the beginning of a movement, current flows through coils C and B, and resistance U in series, and draws in the core D, causing the bridge I′ to connect L′ and M′, which shunts the coils B and U, so that the operating and indicating currents flow only through the coil C, of a very low resistance, but having sufficient turns to hold the core D in place. The bridge I will touch J and K before I′ touches L′ and M′, so that if the current happened to come from a foreign source without the lever having been moved, current would also flow from the last operating wire, which is still in connection with battery, through coils C′, B′, bridge I, and the motor, and would hold I′ away from L′ and M′, by drawing in the core D′. This current will run the motor light in the direction it ran in making the last movement without energizing the clutch. The contact K is provided with a head on its inner end, which makes connection with a contact X, when K is pushed outward by the spring, but when K is pushed in by the bridge I, it is separated from X. The object of this is to cause the cut-off current to flow only through the safety contacts J and K, and thus afford a test of their condition at each movement of the switch.

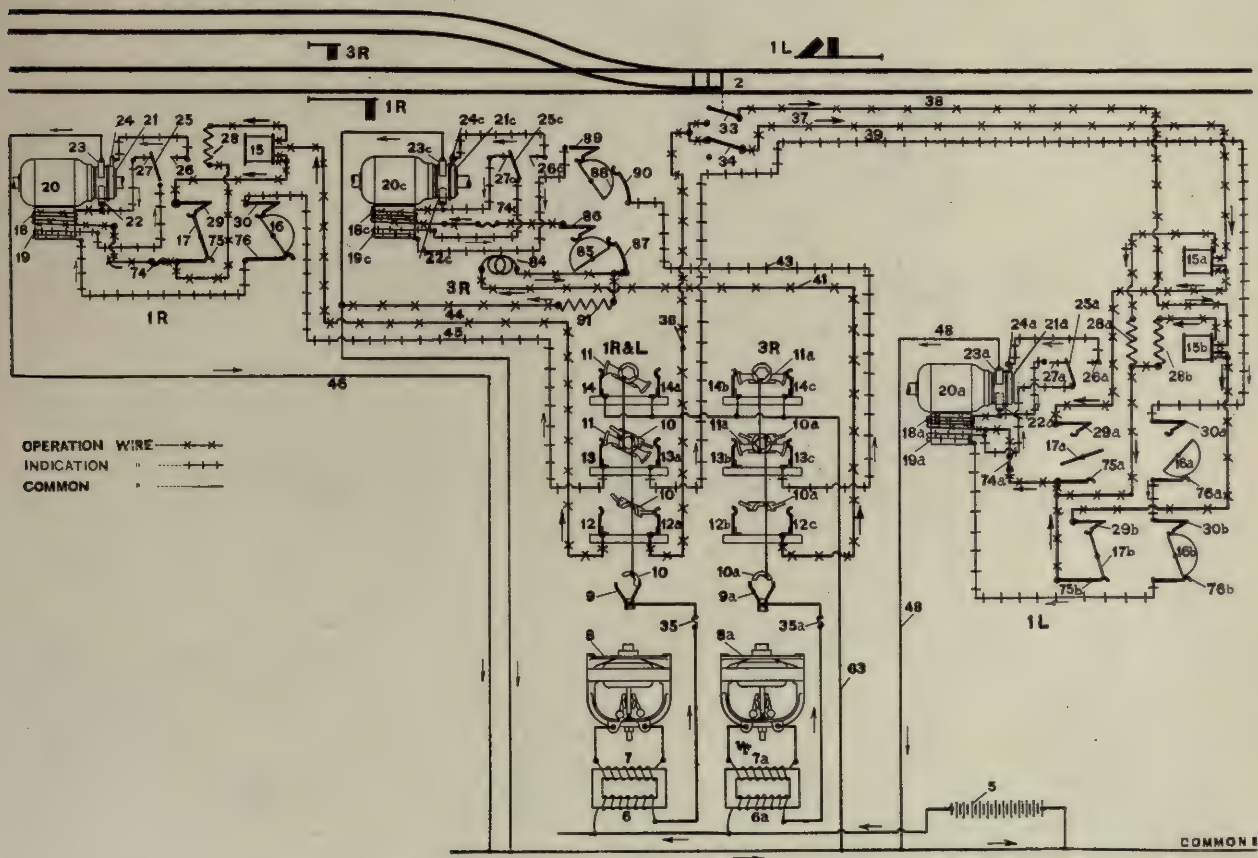


Fig. 1884. Control and Indication Circuits for Electric Interlocking Signals.

bridge I, which will connect the contacts J and K when the core D is drawn into the solenoid, and will connect the contacts L and M when the core D is drawn outward. The levers F and F′ are connected near the lower ends by a spring Z, which causes the bridge I′ to connect L′ and M′, when the core D is drawn into its solenoid A to nearly the full extent. Similarly the contact bridge I is made to connect L and M when the core D′ is drawn into the solenoid A′. The contacts J and K are carried by the slate block N, with springs interposed so that they may be pushed in about 3-16 in. The contacts L and M are fixed to the slate block O. The relation of the parts is such, that the bridge I touches the contacts J and K, while the core D is still 3-16 in. from its complete inward stroke, and the bridge I′ touches L′ and M′ with the core D about 1-16 in. from its full inward stroke. These clearances are allowed for making good contact. Each solenoid has two coils of wire. The coil C has 100 turns of No. 13 B. & S. and the coil B 1100 turns of No. 15 B. & S. The resistances U and U′, each of 20 ohms, are in series with the coils B and B′ at the starting of a movement, and the circuits including them may be called the starting circuits. The coil B is connected to terminals P and Q, and the coil C is connected to the terminals R and S.

When the core D is drawn completely into the solenoid A, the latch T drops into the path of a projection on the lever F′, so that if the magnet A′ is energized while A is still holding its core, the core D′ will be stopped by the latch T before it puts the bridge I′ against J′ and K′. A similar latch, T′, stops the core D under similar conditions. These latches come into play in the action of the cut off current last above mentioned. If in that case the bridge I′ were allowed to move far enough to touch J′ and K′, the safety circuit to be mentioned later would be temporarily closed and cause sparking at the contacts.

The circuits of a single switch can be understood from an inspection of Fig. 1882. In the position of the parts as shown, which is the beginning of the reverse movement, current will flow from battery 1 through primary 2, fuse 3, wire 4, spring 5, bridge 11 (11, 11a and 11 are one piece on machine), spring 9, wire 14, field 16, wire 18, coil C of A, connector 26, coil B of A, wire 20, contacts K′ and X′, resistance U, wire 22, contacts 37 and 38 of knife switch 33, wires 23 and 45, clutch 52 by brushes 50 and 51, armature 53 by brushes 49 and 47, thence by common wire to battery. This current will energize the magnet A, the bridge I will connect J and K, and the bridge I′ will connect L′ and M′. The above circuit remains the same up to wire 18, thence through coil C of A, wire 28, contact M′,

bridge I', contact L', wire 30, contact 35, knife 33, contact 38, to wire 23, whence it is the same as above. The current in the coil C holds the core D and the bridges I and I' in position last noted.

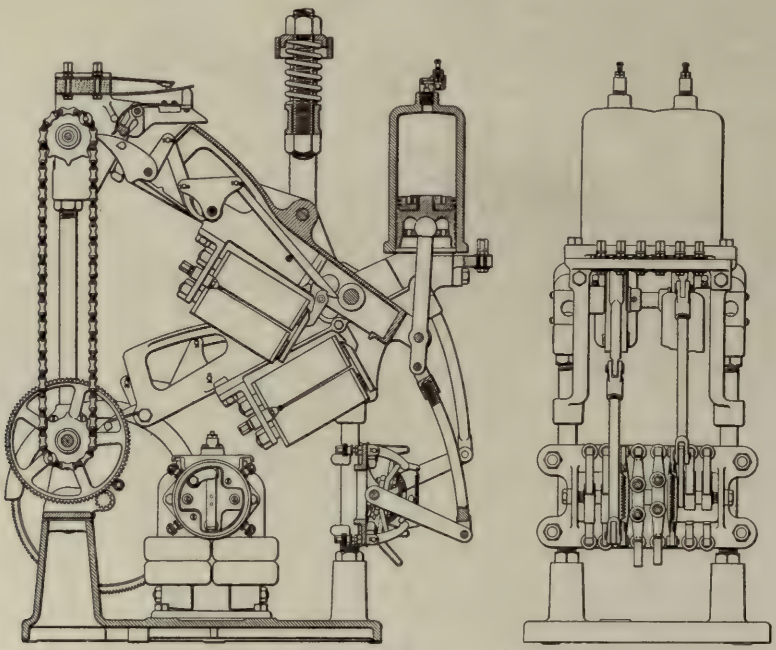
When the switch movement is completed, the knife 33 is moved from contact 38 to contact 36, still remaining in contact with 35. This cuts off the current from the clutch 52, and causes it to flow through wires 43 and 46, indication brush 48, armature 53, brush 47, and common to battery. The current still flows through the coil C, thus holding I and I' in positions noted. The current entering the armature 53, by the way of the brush 48, which bears on a ring connected to a segment of the commutator, is thereby rendered pulsating in character. In flowing through the primary 2 of the transformer, it develops magnetism of a like character in the iron core. This in turn induces alternating current in the secondary coil 55, which flows through the induction motor 56, by means of which the latch is lifted, thus releasing the lever to make its final movement.

The final movement of the lever puts the bridge 12 in contact with spring contacts 8 and 10, which closes a branch circuit, and current flows from armature 53 by way of brush 49, wires 32 and 31, contact J, bridge I, contact K, wire 19, coil B' of A', connector 25, coil C' of A', wire 17, field 15, wire 13, spring 10, bridge 12, spring 8, wire 57, motor 56, and secondary 55 in parallel, and resistance 58 to battery. This current energizes magnet A', draws in its core D', and pulls the bridge I' away from contacts L' and M', thus cutting off all current.

Fig. 1883 shows a crossover with all parts in normal position. To reverse the crossover, the bridge 11 will be moved by the lever to connect the contacts 5 and 9, when current will flow from battery 1 through 2, 3, 4, 5, 11, 9, 14, field 116, wire 60, contacts 137 and 138 of knife switch, wire 62, contacts 64 and 65 of knife switch, field 16, wire 18, coil C of A, connector 26, coil B of A, wire 20, contacts K' and X', resistance U, wire 22, contacts 37 and 38 of knife switch, wires 23 and 45, clutch 52, armature 53, thence through common to battery. This current energizes magnet A, thereby causing the bridge I to connect J and K, and bridge I' to connect L' and M'. The connection of L' and M' shunts the coil B and resistance U out of the motor circuit, as explained in connection with the single switch. When the mechanism connected to armature 53 has moved a short distance, the knife switch 63 is shifted from contacts 64 and 65, to contacts 66 and 67, which breaks the circuit through armature 53, and continues the circuit from wire 62 through contacts 66 and 67, wires 123 and 145, clutch 152, armature 153, thence through common to battery. The switch operated by motor 153 then makes its complete movement, at the end of which, the knife 133 is shifted from contacts 137 and 138 to contacts 135 and 136, which stops the current through field 116 and armature 153, and continues the circuit from wire 14 through contacts 135 and 136, wire 114 to field 16, thence it is the same as that above traced, which caused the preliminary movement of the mechanism operated by armature 53. The current in this last circuit causes the armature 53 to complete the movement, and indicate, which it does as explained in the description of the single switch.

The action of the crossover mechanism may be briefly stated as follows: The armature 53, which is governed by the safety controller starts the movement, and after a short preliminary movement, opens its own circuit, and closes that of 153. Armature 153 then completes its movement, and again closes the circuit to 53, which then completes its movement, and indicates.

To explain the action of the safety controller, in protecting against stray currents, reference will be made to Fig. 1883, which shows a lever in complete normal position. Suppose a live wire to be connected with wire 14 at Y. Current would flow through the magnet A, just the same as though the lever had been reversed. This would cause the bridge I to touch J and K, when a circuit would be closed and current would flow from battery 1, through 2, 3, 4, 6, 11, 10, 13, contacts 139 and 140, wire 113, field 15, wire 17, coils C' and B' of A', 19, K, I, J, 31, 32, armature 53 by brushes 49 and 47, to common This current would energize magnet A', and would hold the bridge I' away from the contacts L' and M'. It would also turn the armature 53 in the direction it ran in making the last movement, because the current goes through the same field 15 that was then used. The rotation of the armature produces a back E. M. F., which limits the current to such a small amount that there is no danger of burning out the magnet A'. This condition would continue as long as the fault remained. When this is removed, the apparatus replaces itself in proper condition for use. If the contact had occurred at Y' on wire 114, the action would be the same.



Figs. 1885-1886. Style "B" High Signal Mechanism, Adapted to Electric Interlocking.

For high signals, use is made of the ordinary Style "B" electric semaphore (See Page 69), with the addition of a third brush to the motor, to give the indication in a manner similar to that described for the switch machine, with other slight changes made necessary by the use of a higher voltage. The high signal mechanism is illustrated in Figs. 1885-1886.

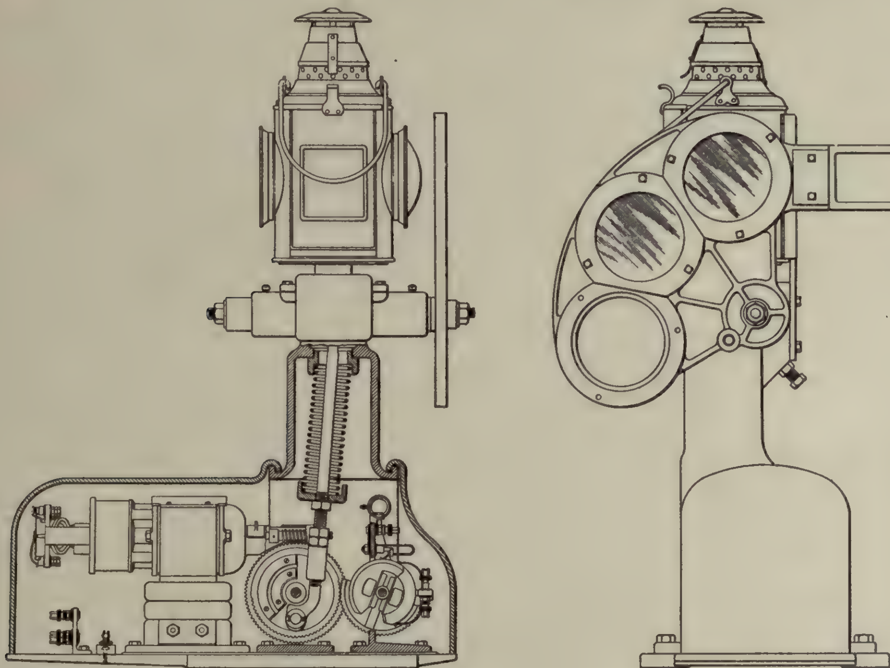
The dwarf signal, Figs. 1887-1888, is actuated by an electric motor, similar in all respects to that used in connection with the high signals. The motor drives, by means of a worm gear, a horizontal shaft to which the armature of an electro-magnetic clutch is fixed. The other part of the clutch, enclosing the exciting coil, is fitted loosely on the shaft. This loose part of the clutch has a crank pin affixed, to which the operating rod of the signal is attached. When the signal is at normal or stop position, the crank pin is vertically under the shaft; when clear, the crank pin is about 45 degrees above the horizontal. The exciting coil of the clutch is connected in series with the motor, and when energized by the operating current, both the motor and clutch are excited, the first causing the clutch armature to rotate, and the second causing the loose part of the clutch to adhere to the armature and move with it. When the signal reaches the clear position, a circuit switch cuts

in sufficient resistance to reduce the holding clear current to a very small amount and to stop the motor. The dwarf signal is locked in the normal position by means of a hook-shaped formation on the eye of the operating rod, which engages with the shaft carrying the clutch, if the rod is moved upwardly a very short distance. Sufficient lost motion is allowed in the crank pin hole to permit a slight upward movement of the rod without turning the clutch.

The signals are protected against improper movements due to stray currents, by means of a fuse placed in the signal operating circuit between the slot coil and the motor. When the signal lever is in the normal position, the indication wire is connected to the common wire, and as the indication wire

consequently in this case the field magnets would not be energized so that the armature would not rotate.

Fig. 1884 shows the arrangement of signals at a turnout from a main track. The two high signals are operated by lever 1, the single arm signal in the right-hand position of the lever, and the double arm in the left-hand position. Selection between the two arms of the high signal is effected by the switch box on switch 2. The dwarf signal is controlled by lever 3 in its right-hand position. Lever 1 is shown reversed to the left, and upper arm of 1-L is clear. The current for clearing this signal flows from battery 5, through primary 6 of indication transformer, fuse 35, switch 9, contacts 10 and 12a, wire 36, contact 34, wire 37, series slot coil of 15a,



Figs. 1887-1888. Motor Dwarf Signal.

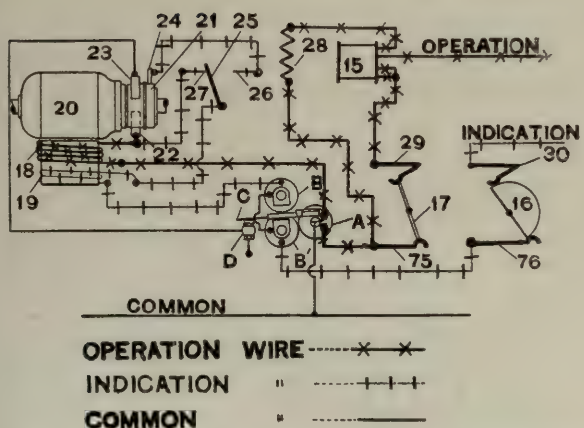


Fig. 1889. Circuits for Signal with Safety Circuit Control.

is also connected to the control wire at the signal motor, both being connected to the same brush on the armature, a current which might reach the control wire would be short circuited back to battery through the indication wire, and would cause a very heavy current to flow and blow the fuse in the operating circuit, thus cutting off current from the signal motor and preventing a false movement. If a contact with a foreign source should occur beyond the fuse, it would also be beyond the slot, so that the slot magnet would not be energized and the signal would not clear. The same arrangement is followed in reference to the safety controller in connection with the switch motor. The coils of the magnets referred to are both placed between the field coils of the motor and the armature, so that if the contact should occur beyond these protecting magnets, it would also be beyond the field magnet coils, and

contacts 29a, 17a, 75a, fuse 74a, field coil 18, brush 22a, armature of signal operating motor, brush 23a, wire 48, to common. When the signal is clear, the contact 17a is separated from 29a and 75a, but this break is shunted by the shunt coil of slot magnet 15a, and the resistance 28a, which permits only a small current to flow, but sufficient to hold the signal clear. To put the signal normal, the lever is moved toward normal position until stopped by the indication latch, in which position 10 makes contact with 13a, but is separated from 12a. The separation of 10 and 12a breaks the circuit through the holding coil of the slot magnet, and allows the signal to go to normal position. When the signal is normal, 16a makes contact with 30a, and completes a circuit so that current flows from battery 5 through primary 6, fuse 35, switch 9, contacts 10 and 13a, wire 39, contacts 30a, 16a, 76a, 30b, 16b, 76b, field coil 19a, tongue 25a of centrifugal controller, contact 27a, brush 22a, armature of signal motor, brush 23a, and wire 48, to common. This causes the signal motor armature to rotate, and when it has acquired sufficient speed, the tongue 25a is moved over to the contact 26a, when the current will enter the armature through the brush 24a and collector ring 21a, instead of the brush 22a. This causes the current to undulate and produces undulating magnetism in the core of the transformer, thereby inducing an alternating current in the secondary coil 7 of the indication transformer, which flows through the coils of the indication motor 8, lifts the latch by means of centrifugal action and releases the lever, permitting it to be put in normal position.

If the switch 2 had been reversed, the contact arm 33, instead of 34, would have been in contact with control wire 36, and the current would have passed from wire 36 through contact 33, wire 38, slot magnet 15b, and contacts 29b, 17b and 75b. This would have cleared the lower arm. The circuits for the single arm high signal, and the dwarf signal are in every respect similar to those just described. The clutch 84 of the dwarf signal replaces the slot magnet 15 of the high signal.

Fig. 1889 illustrates a safety controller for signals, intended to take the place of the fuse 74. It is superior to the fuse in

some respects, as it replaces itself ready for operation when the fault is removed, and is independent of the strength of current. Of course a certain minimum current is required to operate it, but this minimum need not be greater than the signal operating current, as is the case with the fuse. It is similar in general appearance and mode of operation to the common polarized relay, but has no permanent magnet. The permanent magnet of the common polarized relay is replaced

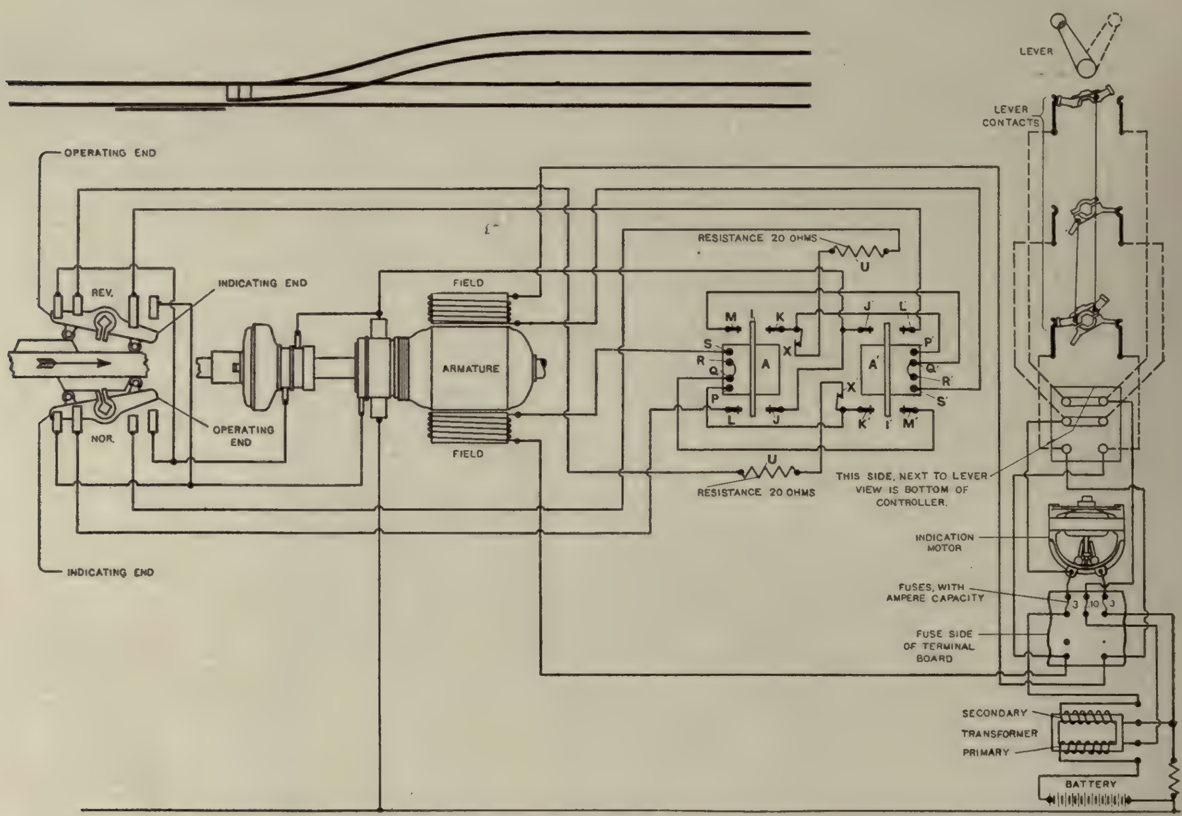


Fig. 1890. Circuits for Single Switch; Lever and Switch Normal.

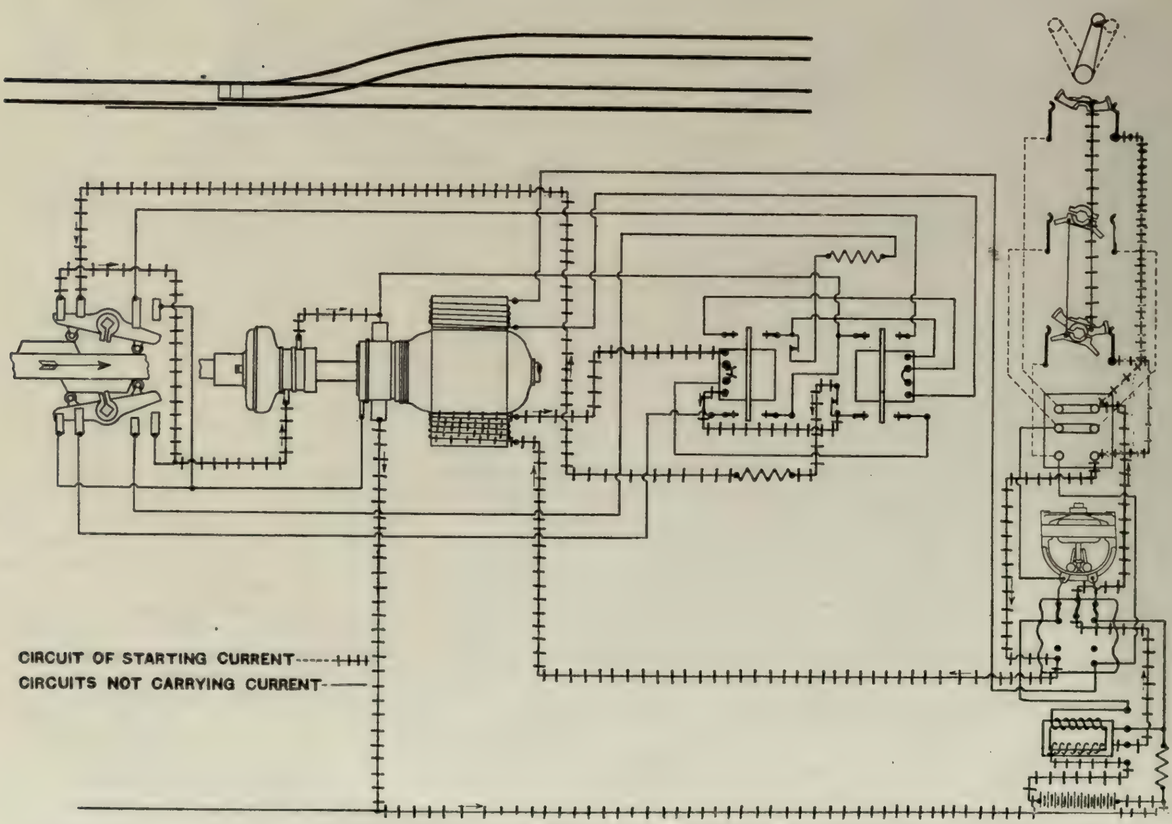


Fig. 1891. Circuits for Single Switch; Switch Normal Lever Against Reverse Stop; Starting Circuit for Reverse Movement Energized.

in this instrument by the single spool electro-magnet A. The double electro-magnet B—B′ is the usual electro-magnet of the polarized relay. To move the armature, therefore, requires current in both A and B—B′, and these two currents must flow in a certain direction relatively to each other. The signal control circuit is taken through the magnet A, the indication circuit through magnet B—B′, and the connection of the signal motor to common, goes through the contacts C and B,

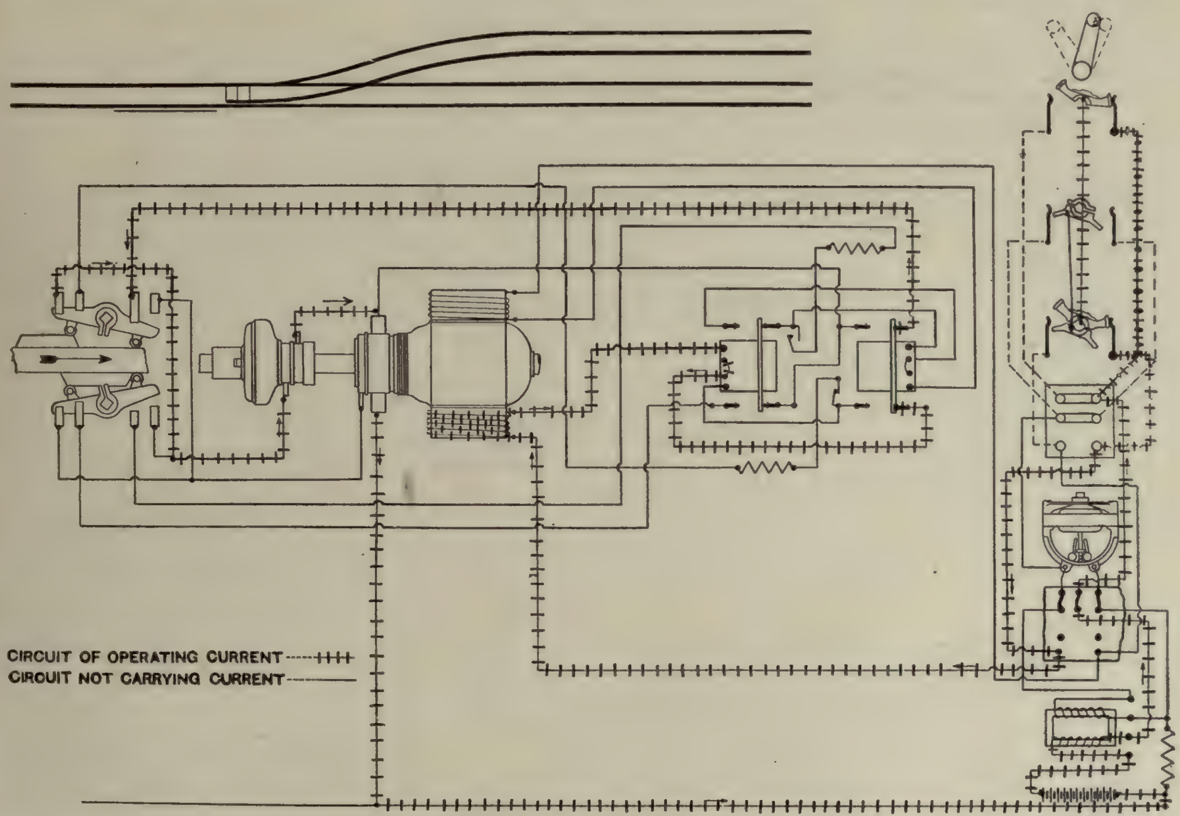


Fig. 1892. Circuits for Single Switch; Lever Against Reverse Stop. Right-Hand Contact Bridge of Circuit Controller Has Moved Against the Back Contacts; Switch Beginning to Move from Normal to Reverse.

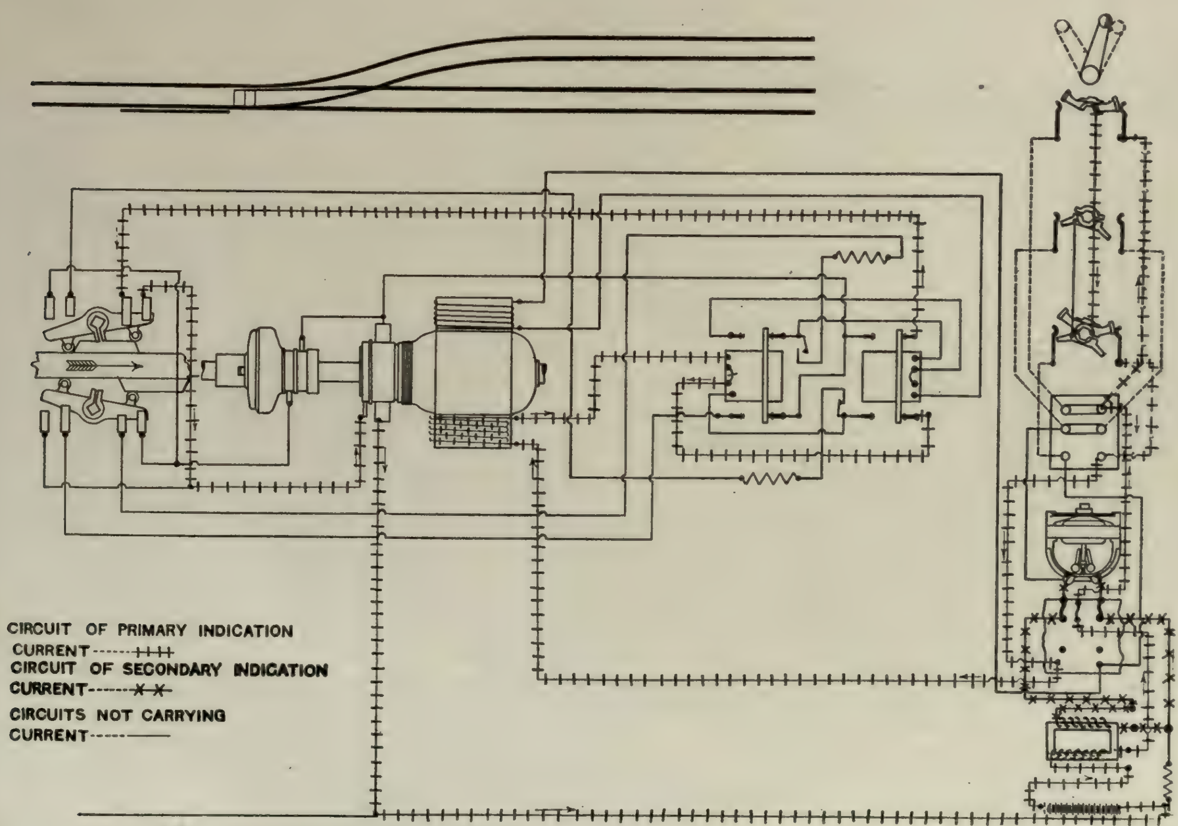


Fig. 1893. Circuits for Single Switch; Lever Against Reverse Stop; Switch Reversed. Knife Switch Actuated by Mechanism Has Opened Operating Circuit and Closed Indication Circuit.

controlled by the relay. When the signal is operating, current flows only in A, when it is indicating, the current flows only in B—B′, and in neither case is any effect produced on the armature which remains stationary, holding the common return circuit closed. When the signal lever is normal the indication wire is connected to common at the lever. If then a live wire should make contact with the control wire, a current would flow through slot magnet 15, contacts 29 and 75, magnet A,

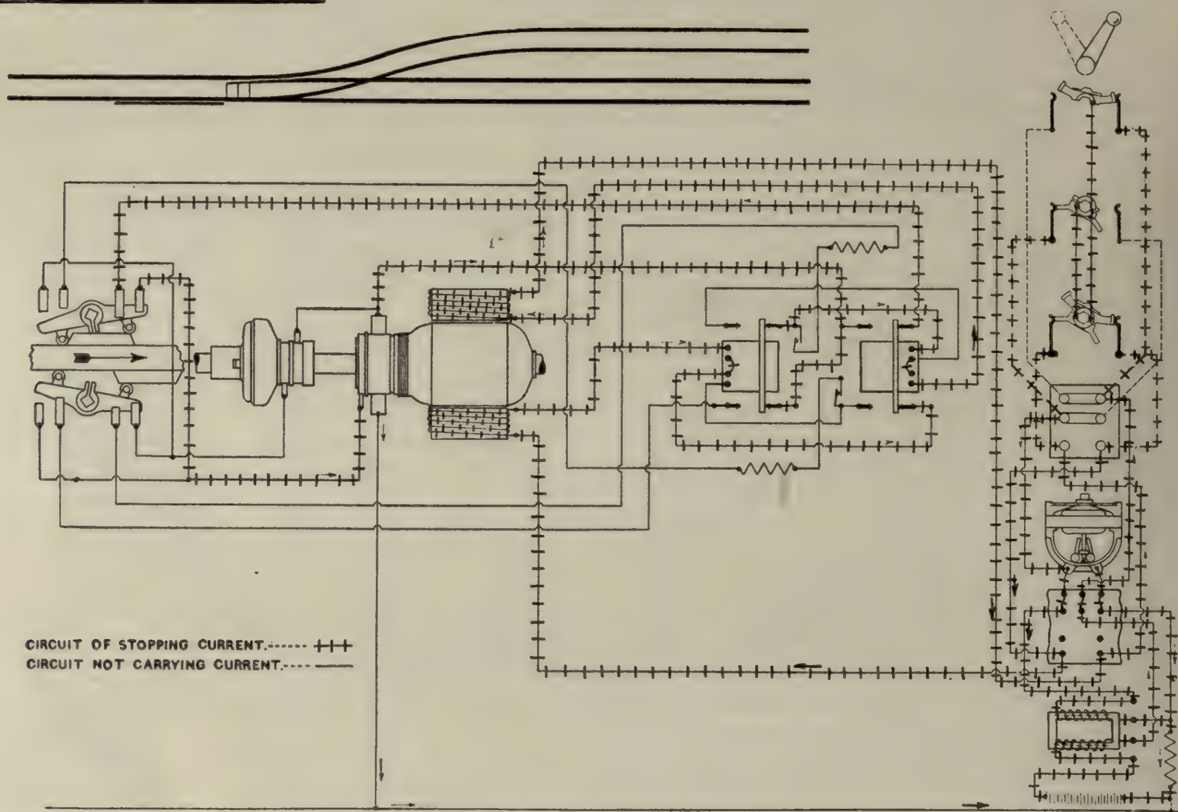


Fig. 1894. Circuits for Single Switch; Lever and Switch Reversed; Stopping Circuit Closed by Final Movement of Lever.

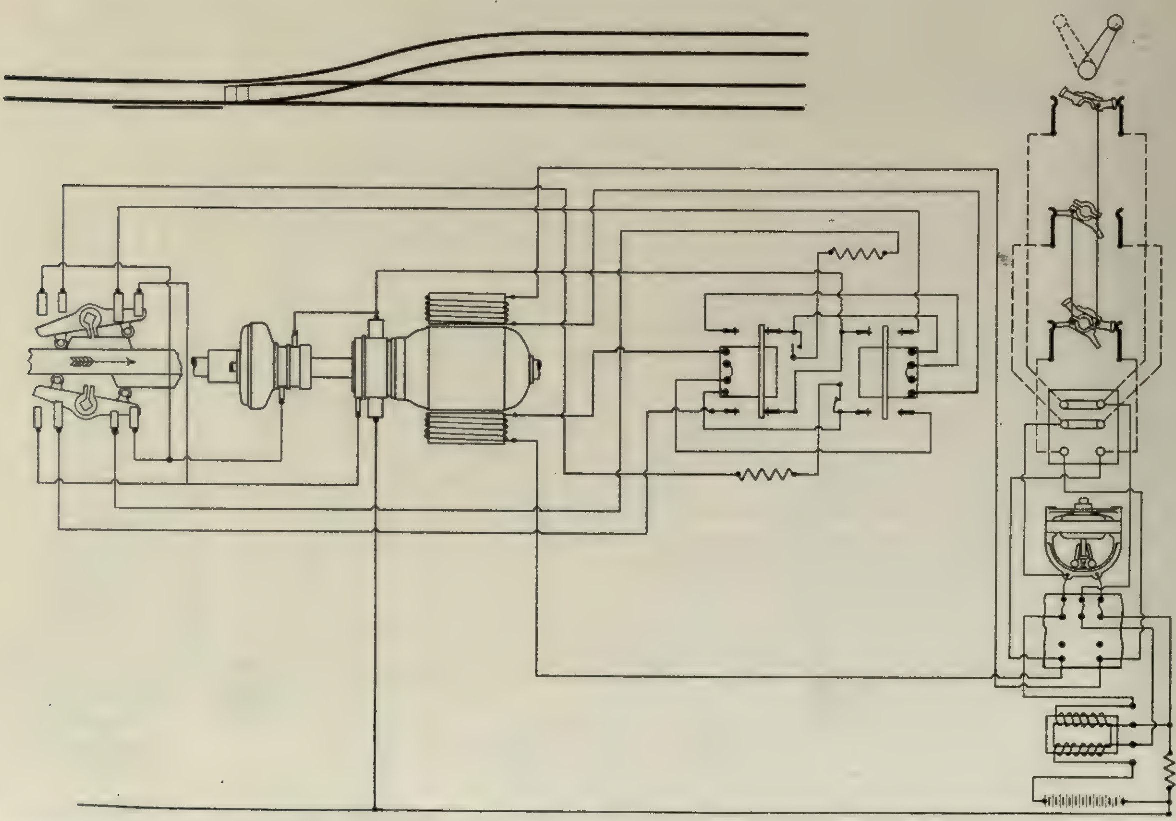


Fig. 1895. Circuits for Single Switch; Lever and Switch Reversed; Stopping Current Has Opened Battery Circuit by Moving Right Contact Bridge of Circuit Controller to Center.

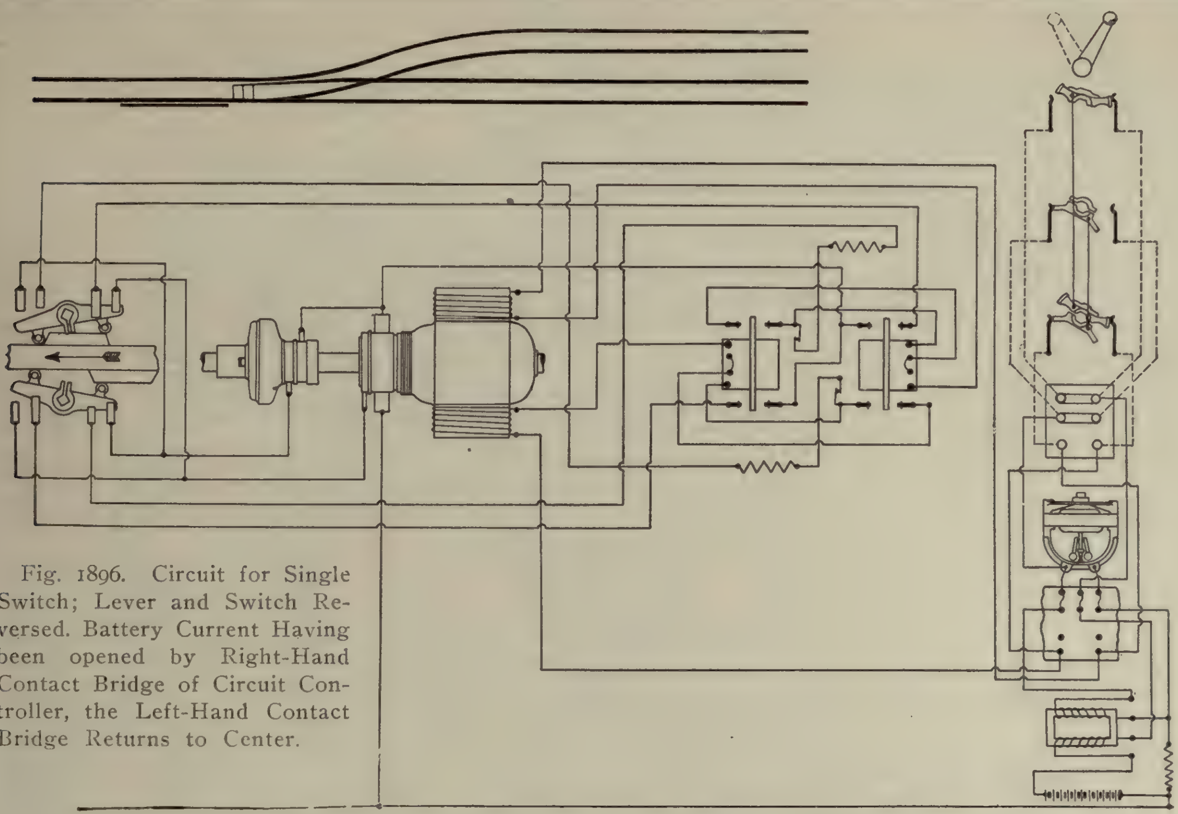


Fig. 1896. Circuit for Single Switch; Lever and Switch Reversed. Battery Current Having been opened by Right-Hand Contact Bridge of Circuit Controller, the Left-Hand Contact Bridge Returns to Center.

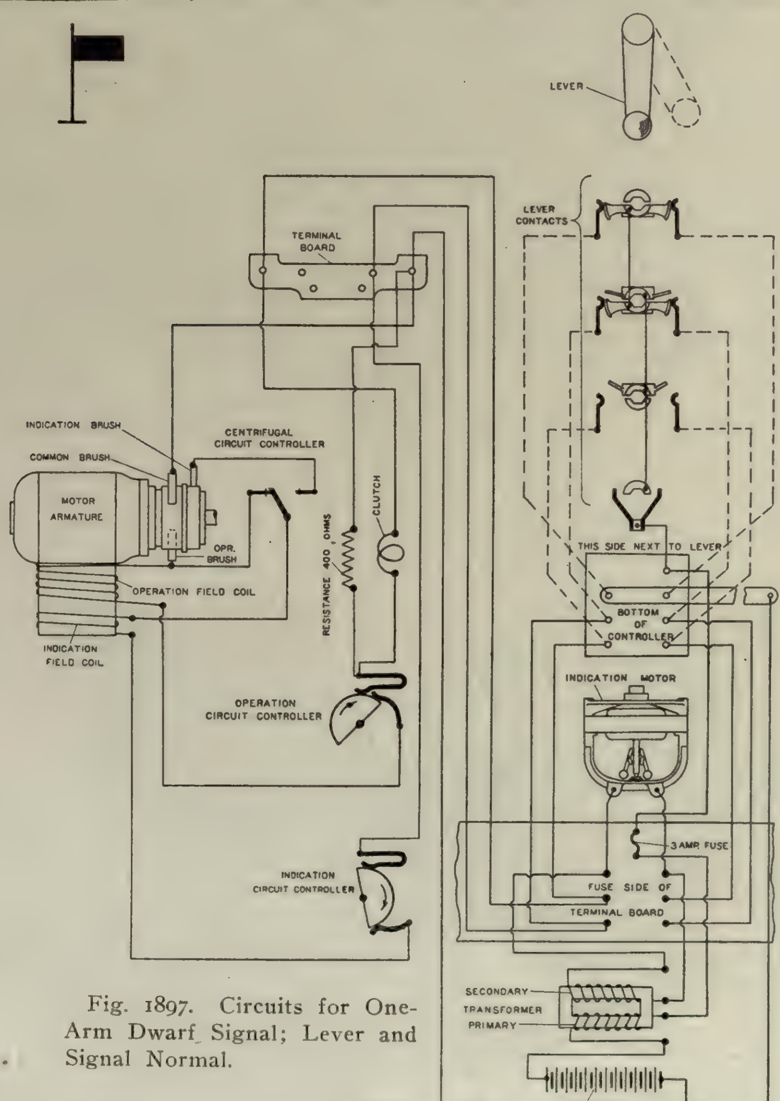


Fig. 1897. Circuits for One-Arm Dwarf Signal; Lever and Signal Normal.

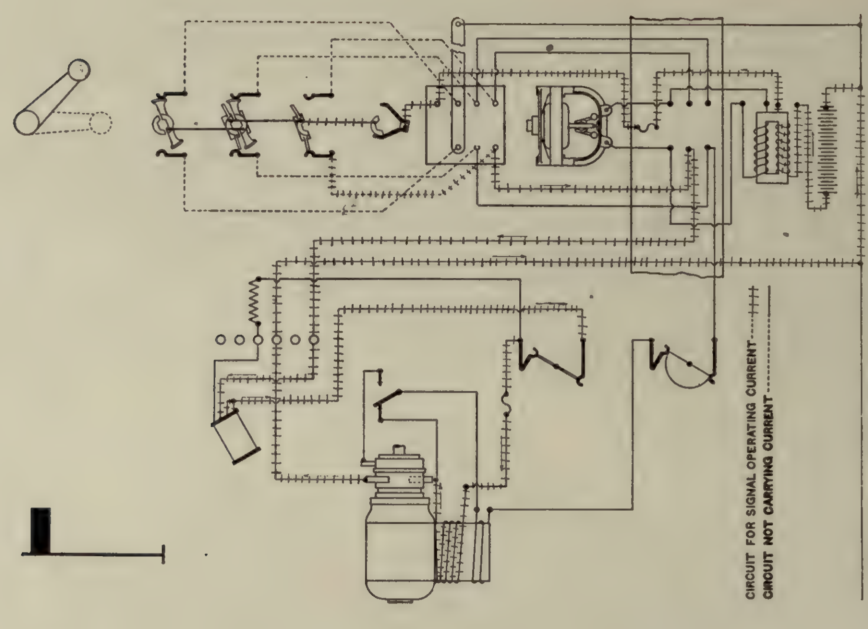


Fig. 1899. Circuits for One-Arm High Signal; Lever Reversed; Signal Normal; Circuit Closed for Clearing Signal.

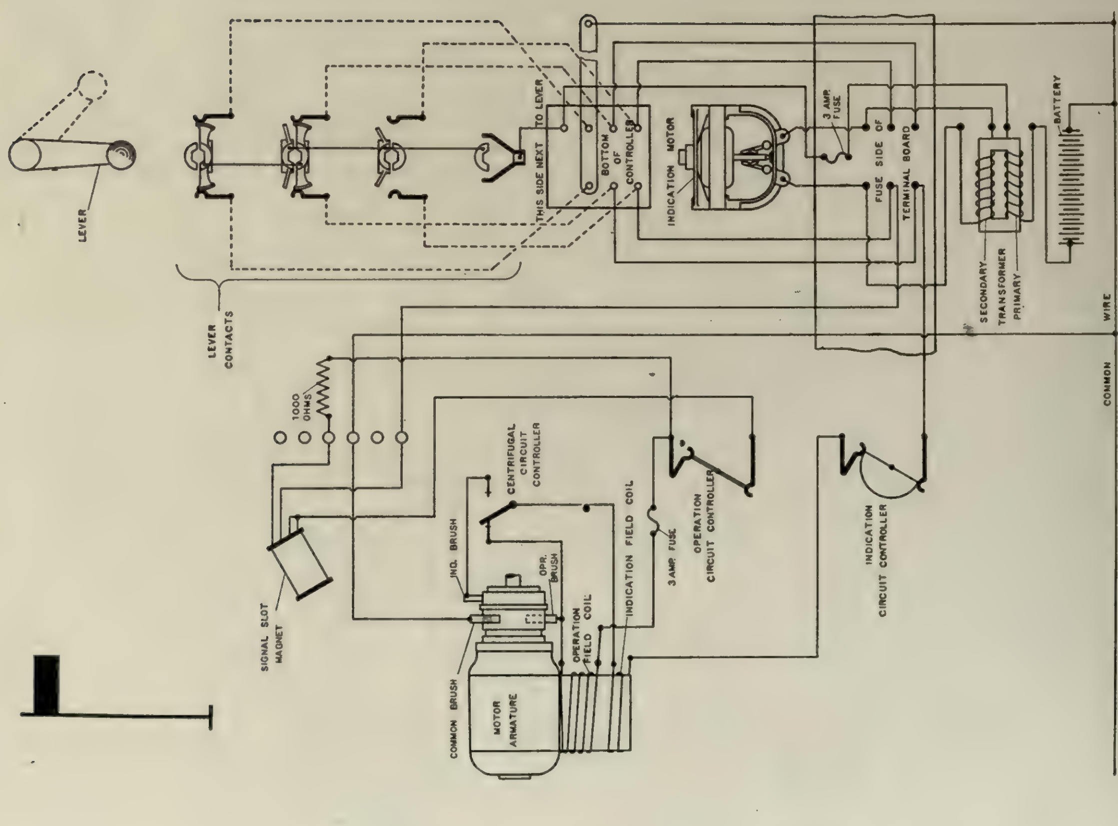


Fig. 1898. Circuits for One-Arm High Signal; Lever and Signal Normal.

field coil 18, contacts 27 and 25, field coil 19, magnet B—B′, contacts 76 and 30, thence through indication wire to common. This would energize both magnets A and B—B′, and the connections are so arranged that the direction of flow is right to move the armature C away from the contact D and thus open the motor return circuit. This condition would be maintained until the fault is removed, when the armature would replace itself in contact with D.

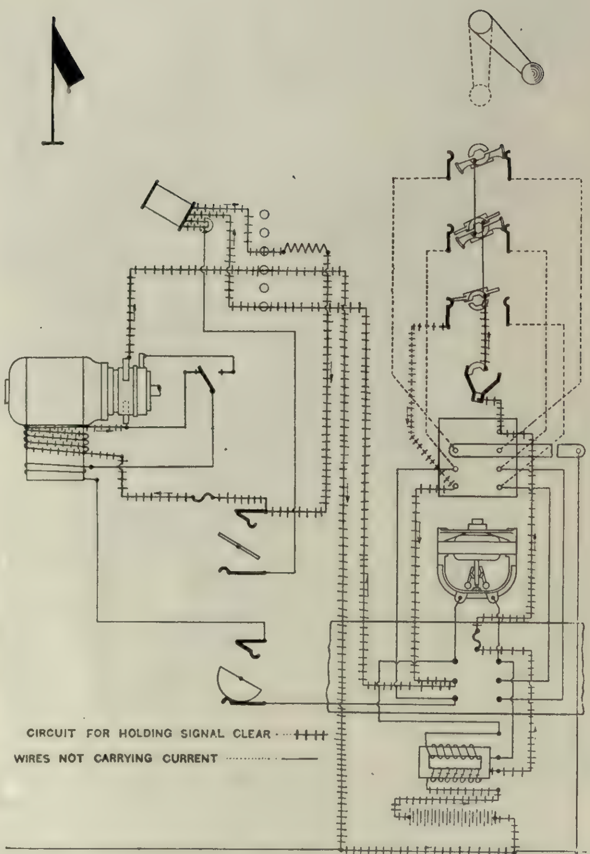


Fig. 1900. Circuits for One-Arm High Signal; Lever Reversed; Signal Clear; Circuit Energized for Holding Signal Clear.

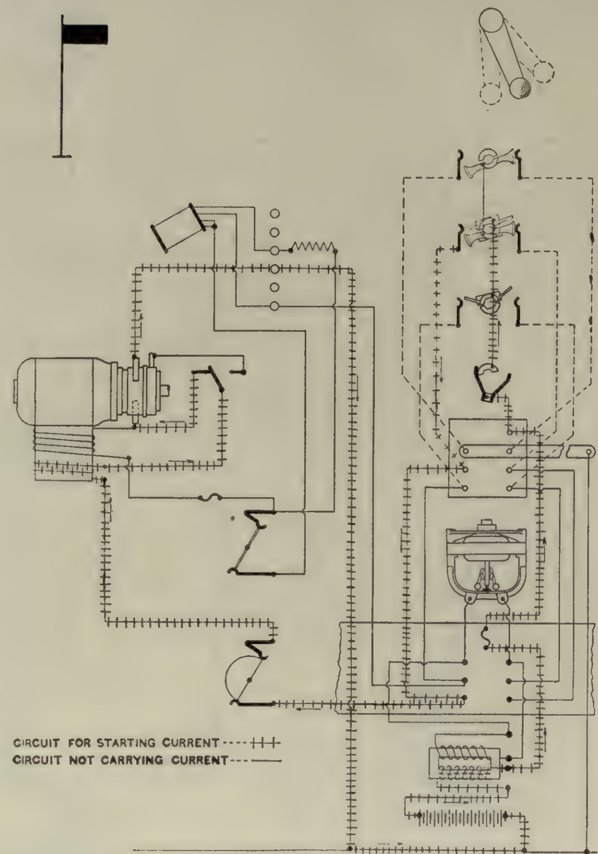


Fig. 1901. Circuits for One-Arm High Signal; Lever Against Stop; Signal Normal; Circuit for Starting Motor Before Indication Circuit is Closed.

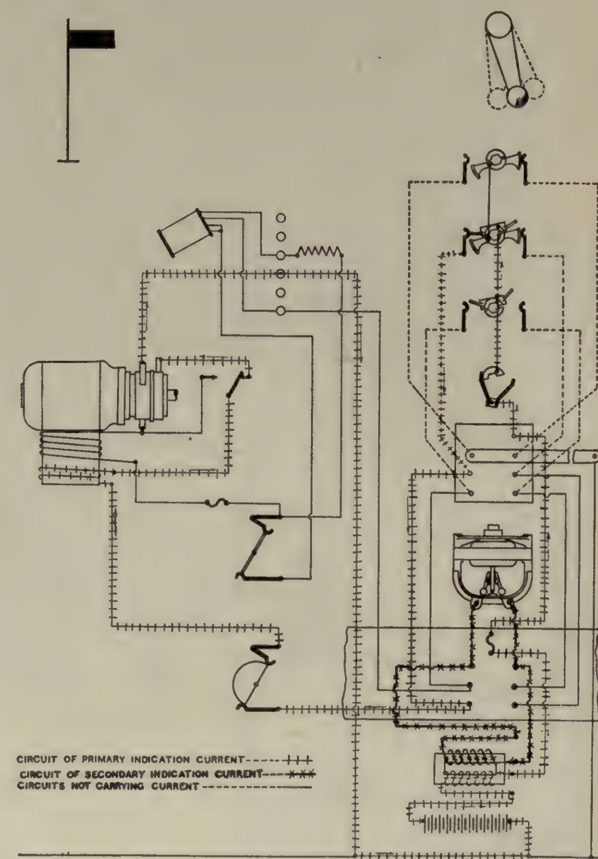


Fig. 1902. Circuits for One-Arm High Signal; Lever Against Stop; Indication Circuit Closed by Centrifugal Circuit Controller.

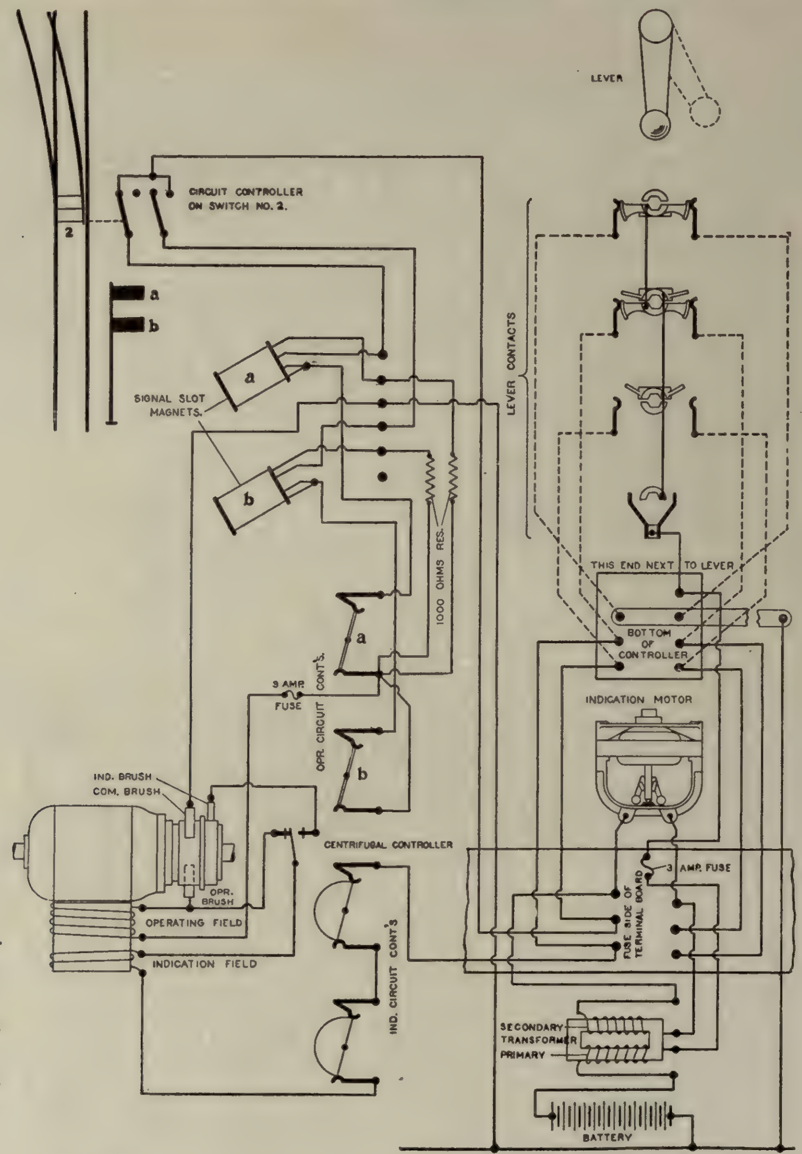
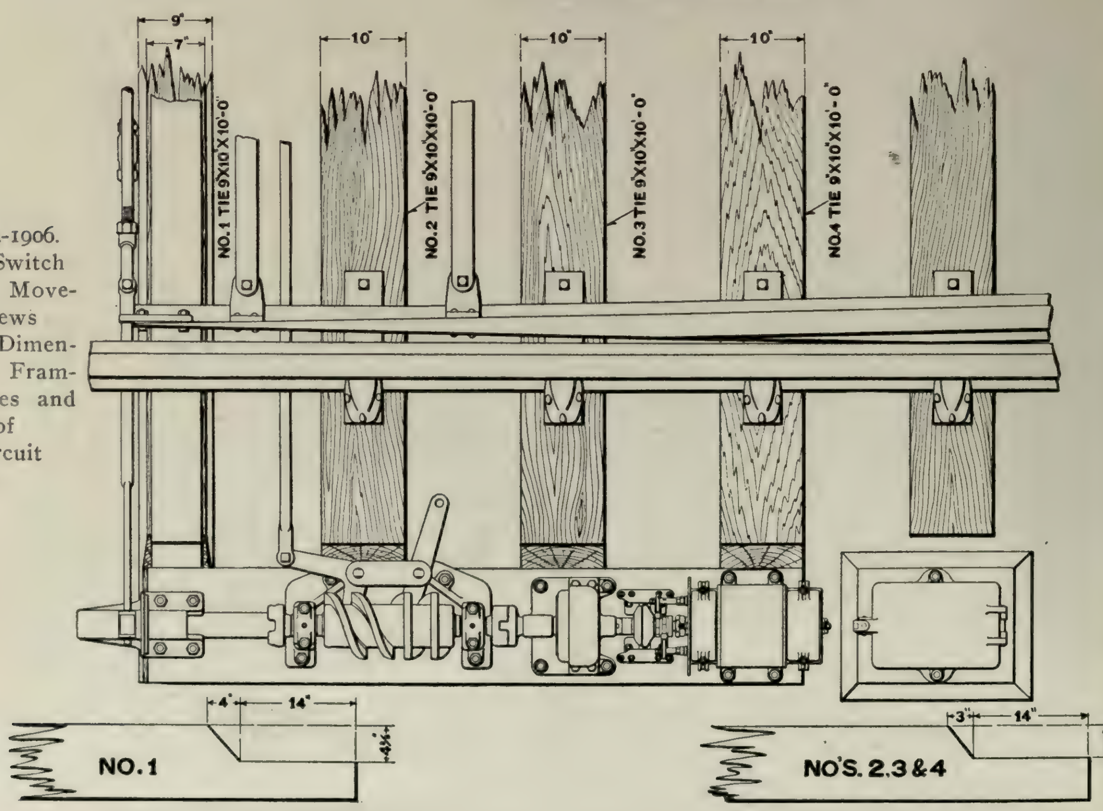


Fig. 1903. Circuits for Two-Arm High Signal; Lever Signal and Switch in Normal Position.



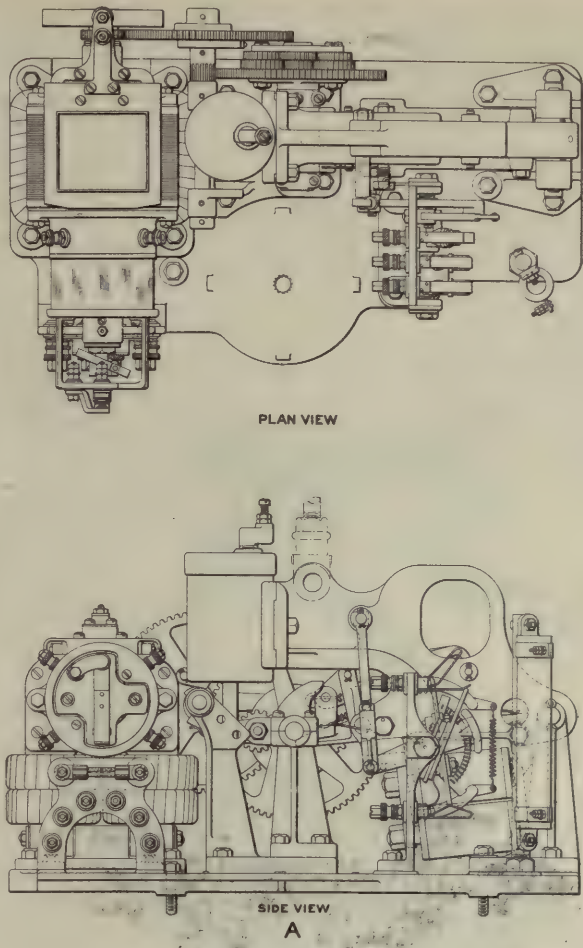
Figs. 1904-1906. Electric Switch and Lock Movement. Views Showing Dimensions and Framing of Ties and Location of Safety Circuit Controller.

MULTIPLE UNIT ELECTRIC INTERLOCKING MACHINE.

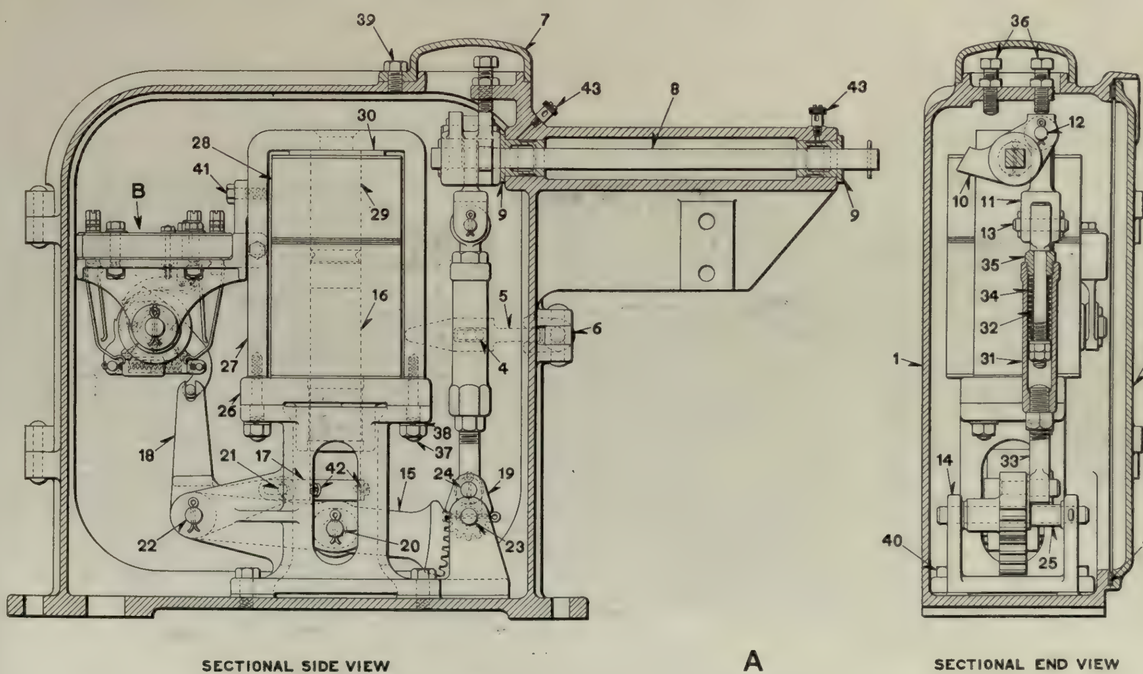
The machine derives its name from the fact that each lever is an independent unit in itself and may be removed by taking out two screws.

Fig. 1907. Multiple Unit All-Electric Interlocking Machine. Eight Levers. Union Switch & Signal Co.

The lever movements are novel; the first is longitudinal movement, actuating the mechanical locking in a similar manner to the latch on a mechanical machine. The intermediate movement is in the arc of a circle and operates controllers for the switch or signal circuits. The final movement is automatic and takes place after the indication has been received, completing the movement of the locking exactly the same as on mechanical latch locking machines.



Figs. 1908-1909. Mechanism for High Voltage Motor-Driven Dwarf Signal Slot-Arm Type.



Figs. 1910-1911. Mechanism for Solenoid Dwarf Signal.

SLOT-ARM DWARF SIGNAL.

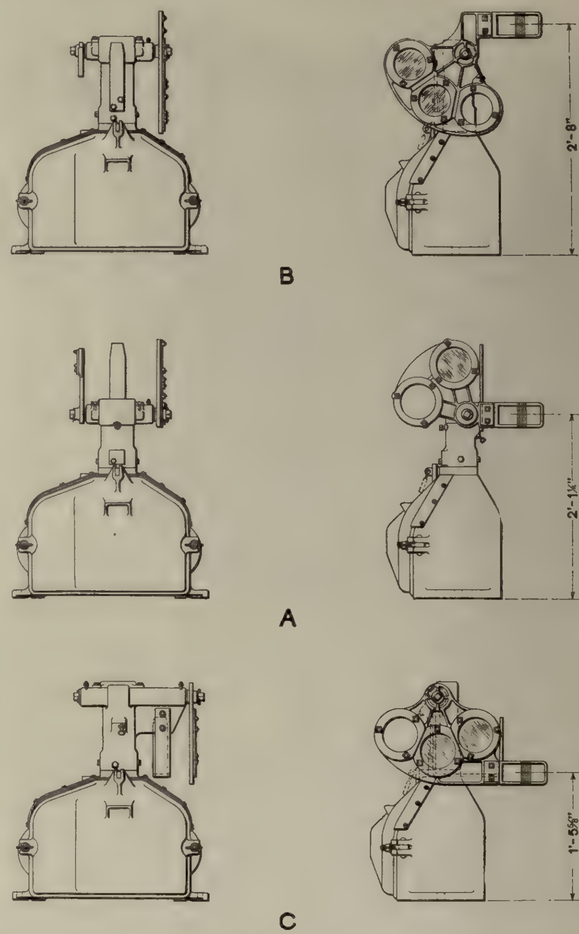
The dwarf signal shown in Fig. 1912 is actuated by an electric motor, similar in all respects to that used in connection with high signals. The operation is as follows:

When the signal is in the stop position and current is applied to clear it, current passes through the slot coils and motor in multiple. The motor revolves the gears, which in turn by means of a crank on one of the gears, carries the slot arm up and the signal assumes the clear position. When the slot coils are de-energized the armature falls away from the coils, releases the slot arm latch and the signal returns to the stop position by gravity.

Fig. 1912. Slot-Arm Dwarf Signal. Union Switch & Signal Company.

MOTOR DWARF SIGNAL.

This signal is for use in connection with 110 volts d. c. interlocking work and is arranged to work as a two-position signal in the upper or lower quadrant.



Figs. 1913-1918. One-Arm Motor-Driven Dwarf Signals. Slot-Arm Type. 60 and 90 Deg. Lower Quadrant and 90 Deg. Upper Quadrant Indications. Union Switch & Signal Company.

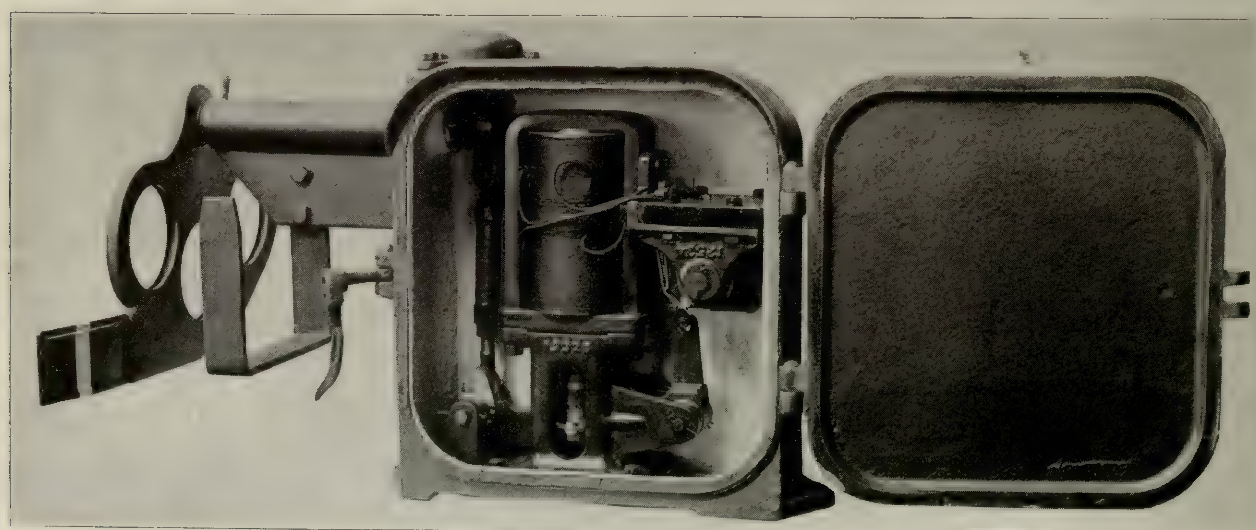


Fig. 1919. Union Solenoid Dwarf Signal.

FEDERAL SIGNAL COMPANY.

The machine is in appearance a miniature Saxby & Farmer mechanical interlocking machine but fitted with locking of the Stevens type similar to that used in the low pressure pneumatic system, arranged, however, in a horizontal instead of a vertical plane. The machine is equipped with circuit controlling and indicating devices to adapt it for use in electric interlocking and the following parts (specially pertaining to this machine) are employed for the purpose of controlling the various electrical circuits used in the system: Lock slide, connected directly to the lever by a pin, and indication and safety magnets supported on the magnet girder; machine controller and terminals mounted on a slate base, the contact slide of the controller being connected to the lever by a bell crank and link; fuse panel below machine controllers and accessible independently of machine controllers which are enclosed and locked within the casing surrounding the machine; solenoid electric lock, the plunger of which engages with an extension of the mechanical locking tappet; and low voltage circuit controller, connected by a bell crank and links to the end of the rocker as shown in solid lines, or by a link directly locking plate, the plunger engaging with an extension piece attached to the tappet, which extension piece also has two shallow notches with beveled sides in which rests, when the tappet is in either the normal or reverse position, a short plunger with a button head. The raising of the latch of the lever will operate the tappet which is allowed a little free motion independent of the position of the plunger of the electric lock. This free motion is sufficient to raise the short button-head plunger and cause it to close the lock circuit at the lock by forcing an insulated metal bar into contact with two springs, when, if the circuit is not open at some other point, nor shunted, the plunger of the lock will be withdrawn from the extension piece on the tappet and the tappet be left free to be further moved by the lever.

The low voltage circuit controller shown in detail is for the control of the low voltage track circuits, and its particular feature is the threaded sliding rod carrying the contact wipers which can be adjusted to any required position.

The mercury time release depends for its action upon a certain quantity of mercury being thrown by the movement of the lever into a chamber from which, upon the return

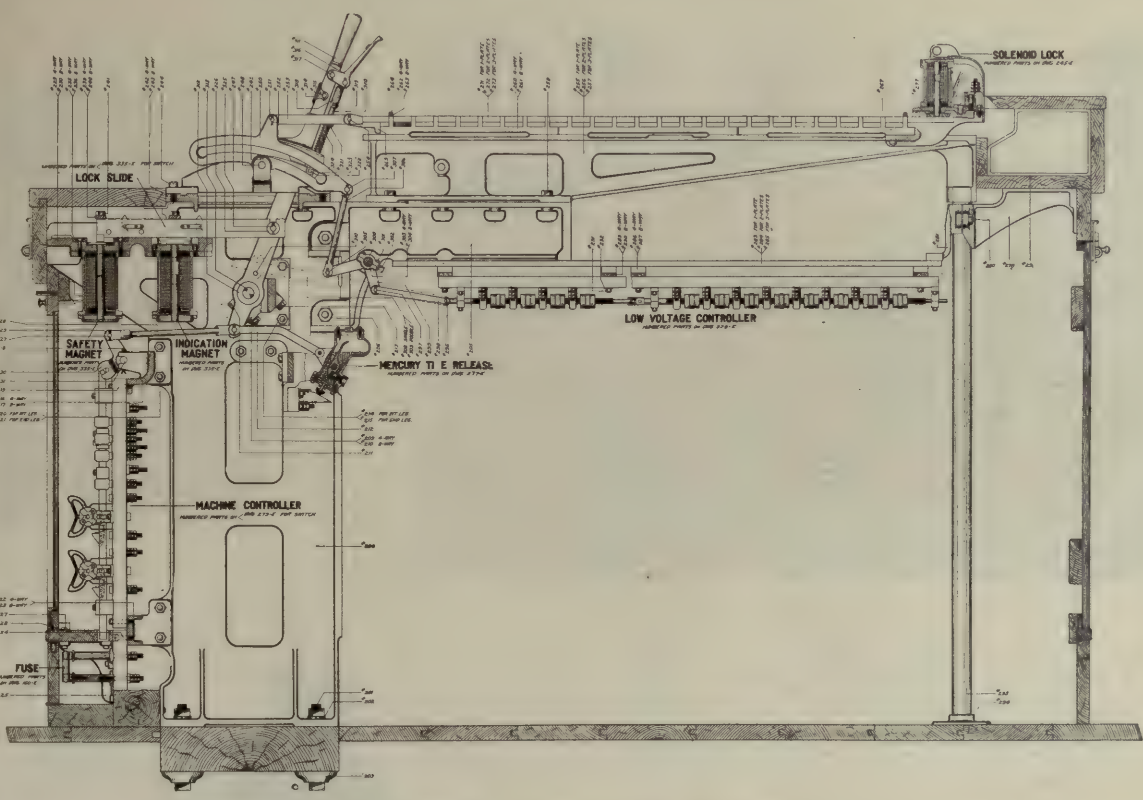


Fig. 1920. Federal Electric Interlocking Machine.

to the lever as shown by dotted lines. A mercury time release is also shown connected by link to the tail of the lever.

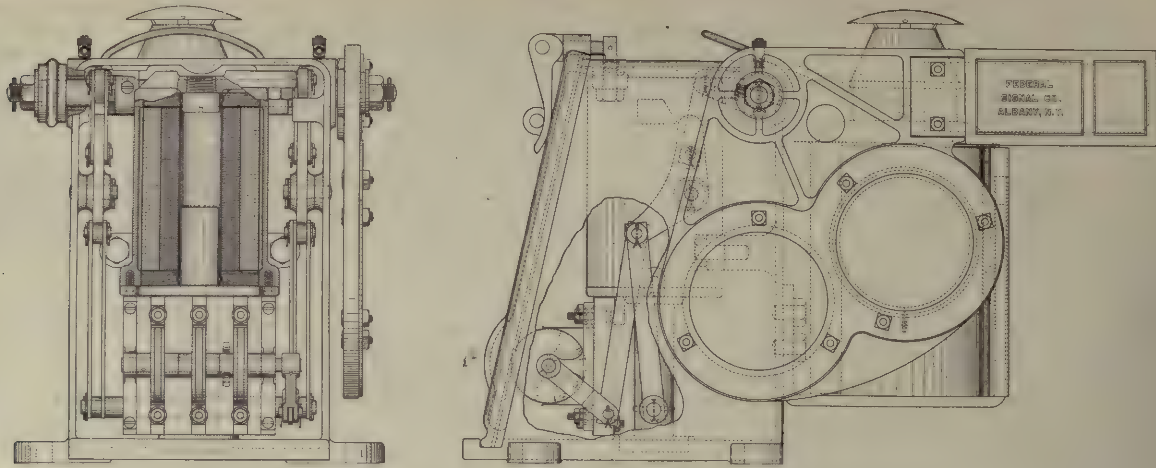
The lock slide moves in guides on the magnet girder and is kept from being lifted out of its position by restraining strips or plates. The lock slide carries two square dogs free to move vertically, but held in their raised position by springs. The tops of these dogs are normally above the top of the lock slide and are beveled so that the movement of the lever and with it the lock slide in either direction causes the beveled parts of the dogs to come into contact with the restraining strips or plates which force the dogs into their lower position, in which position they engage with raised portions of the magnet girder, thus restricting the movement of the lever to the operating positions until the movement of the switch has been completed; the necessary and proper contacts made and broken; and the safety and indication magnets have by their action raised the dogs in the lock slide into their normal position again.

The safety and indication magnets are of the solenoid type and their action is such that if energized, excepting at the proper time in the cycle of the system, the lever becomes locked either in the normal or reverse position; or is restricted to movement between the operating positions. This locking is effected by the head of the magnet engaging with pins on the side of the lock slide.

The solenoid electric lock is attached to the mechanical of the lever to its original position, the mercury can only escape through a restricted channel, the size of the channel being adjustable so that the time taken for the return of the mercury may be varied from 10 seconds to two minutes. The return of the mercury to its original position re-establishes the electrical connection, not by the mercury making metallic contact between two metal points, but by the weight of the mercury distending a suitable diaphragm which forces out a plunger until contact is made between two metal springs. This mercury time release can be applied on any machine or device capable of imparting the necessary movement for transferring the mercury to the "time" chamber.

The Federal Signal Co.'s No. 4 switch gear consists of a cast iron case containing a motor, a train of gears, a switch and lock movement, operating and indicating circuit controllers and a dynamic brake. It may also contain the equivalent of a switch box, but so operated that the controlled circuit is not made until the switch is locked in the desired position.

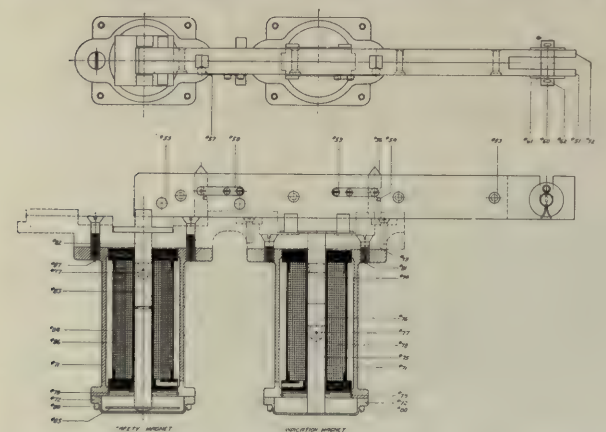
The arrangement and operation of the plungers for locking the switch are such that the switch can only be locked in that position which agrees with the position of the mechanism. This is accomplished by an oscillating connection or link between the main gear and the locking plunger proper and which link operates the latter. This link has on its underside a projection or locking dog which engages in one or other of two notches in the upper edge of the lock rod, and as the



Figs. 1921-1922. Dwarf Signal. Federal Signal Company.

Fig. 1923. Federal Electric Interlocking Machine.

Fig. 1924. Motor Dwarf Signals.



Figs. 1925-1926. Switch Lock Slide with Indication and Safety Magnets.

end of the link carrying the locking dog oscillates from side to side, it follows that the lock rod must be moved to agree or the switch cannot be locked.

The operating and indicating contro'lers are of the slide-type with wipers adjustable as to position and are given the necessary movement by a cam on the main gear.

The electro-mechanical screw hand release illustrated can be adjusted so as to be operated in varying times and can be fitted with one to four pairs of contacts controlling a corresponding number of circuits.

The deflecting bar illustrated differs from others in that the stand is made in two separate parts which allows of their being used in multiple for any angle, the bars themselves being bent as required.

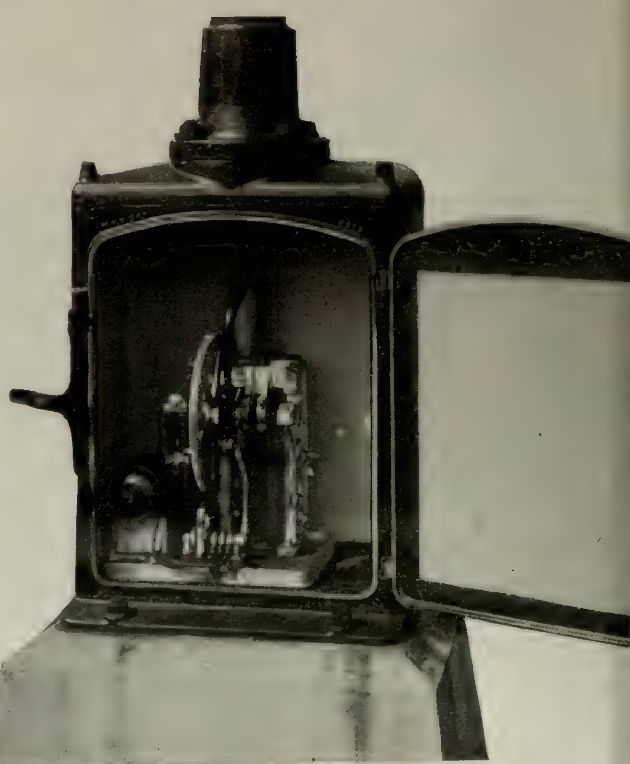


Fig. 1927. Signal Mechanism in Place.

AMERICAN ELECTRIC INTERLOCKING MACHINE.

Fig. 1928 shows a sectional view of the interlocking machine made by the American Railway Signal Company. In the figure the lever is in the indicating position. The locking is of the Saxby & Farmer type, being about one-half the size of the standard mechanical locking. All working parts are assembled on the outside of the main frame, which leaves everything exposed to view, and allows the parts to be easily removed. The contacts are designed to prevent trouble due to their burning on a small arc. All breaks are quick and wide. In their normal and reversed positions, all interlocking levers stand at an angle of about 15 deg. from the vertical. They are latched in both normal and reverse positions.

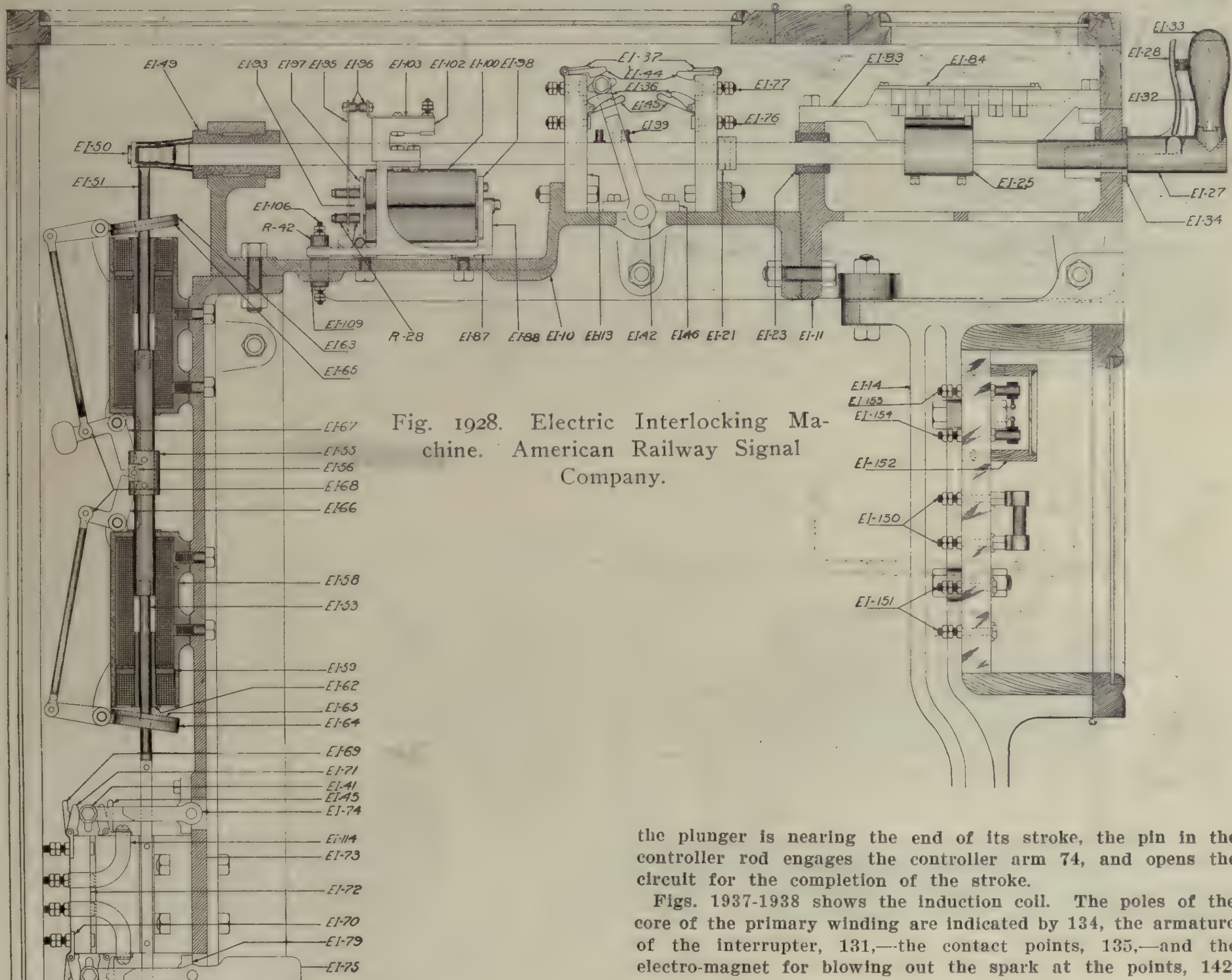


Fig. 1928. Electric Interlocking Machine. American Railway Signal Company.

To operate the machine, the lever man presses the latch 28, releasing the lever. He then twists the lever to the vertical position, which movement, by rotating the square shaft of the lever, moves the locking bar through one-half of its stroke by means of the driving dog 25. This dog is engaged in a driving piece, which is riveted and brazed to the bar. The rotation of the lever shaft also turns the crank 49, which in turn lifts connecting rod 51, the plunger 55, and the controller rod 53. When the lever is in the vertical position, the indication latches 66 and 67 drop into place and prevent further rotation until the indication is received. The lever is then pulled from the machine, moving the controller arm 42 to the reverse position and closing the reverse circuit to the operated unit, the driving dog sliding through the driving piece on the locking bar, and the shaft sliding through the crank 49.

When the operated unit has completed its movement, the indication, which is an induced current from an induction coil, jumps the gap 154-3, and closes the relay points 96, which points close the circuit 4, releasing the indication latch 67 and permitting the solenoid to release its plunger. This final upward movement of the plunger twists the lever through its final movement, completing the movement of the locking bars. When the plunger is nearing the end of its stroke, the pin in the controller rod engages the controller arm 74, and opens the circuit for the completion of the stroke.

Figs. 1937-1938 shows the induction coil. The poles of the core of the primary winding are indicated by 134, the armature of the interrupter, 131,—the contact points, 135,—and the electro-magnet for blowing out the spark at the points, 142.

Fig. 1929. Concrete Interlocking Tower for American Electric Interlocking Plant.

These coils are housed in the cases, as shown, or are put in the signal cases.

Fig. 1939 shows the switch machine. The operation of this machine is as follows: When current is supplied to the control wires, part of it passes through the pole changer box con-

Fig. 1930. Switch Machine and Derail in Service. American Electric Interlocking.

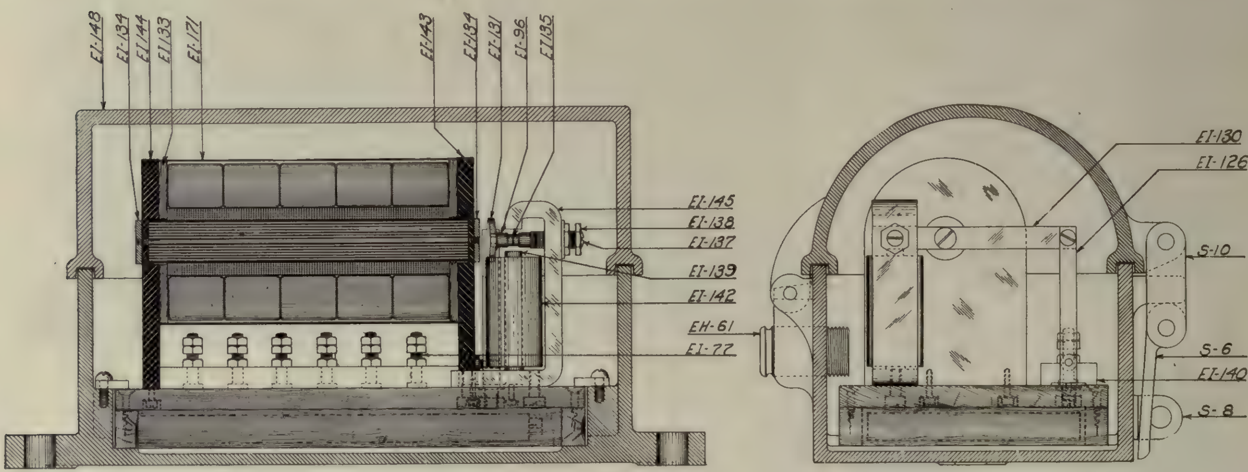
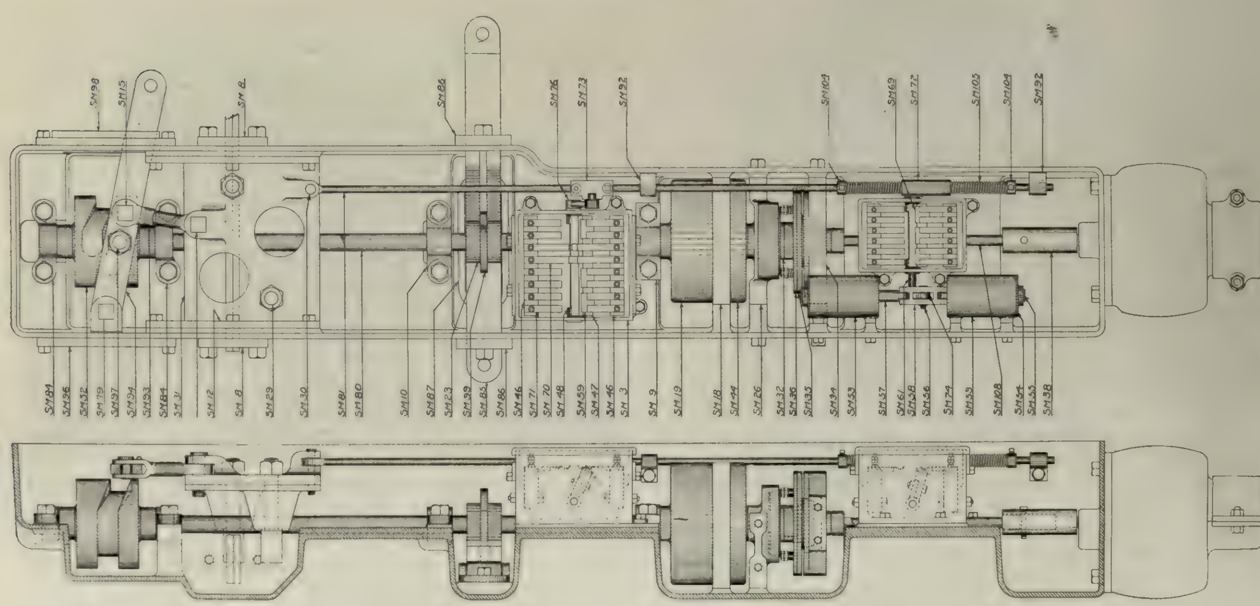
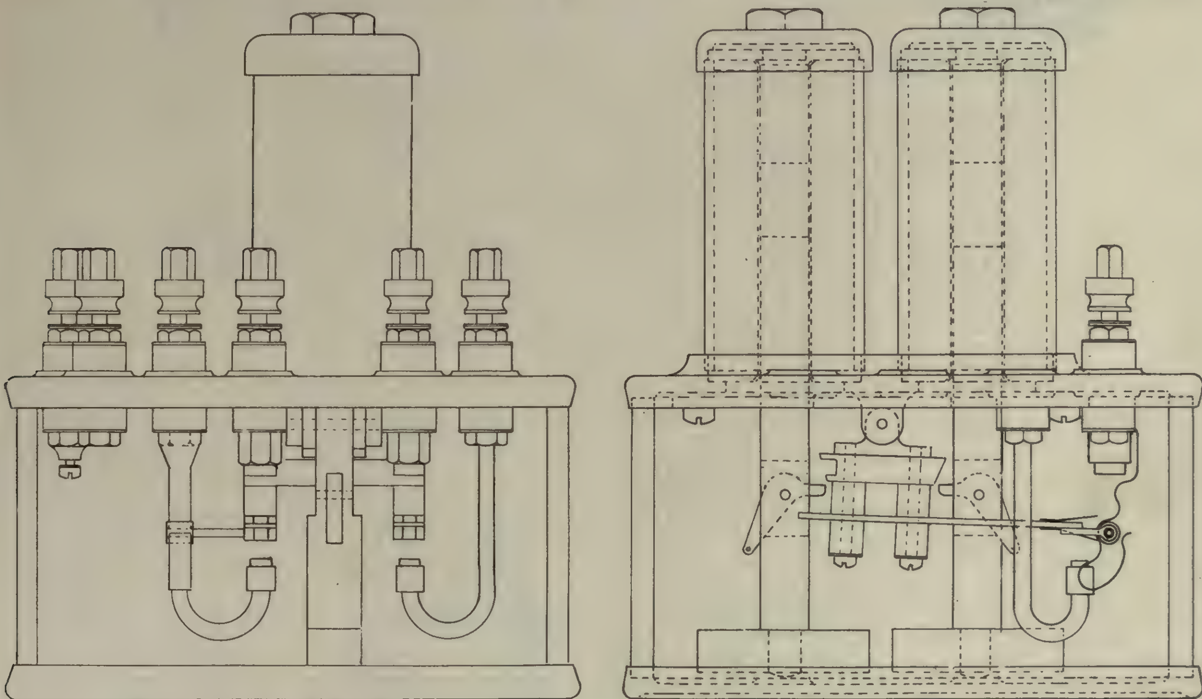


Fig. 1931-1932. High Voltage Induction Coil for Electric Interlocking.



Figs. 1933-1940. American Model B Switch Machine.

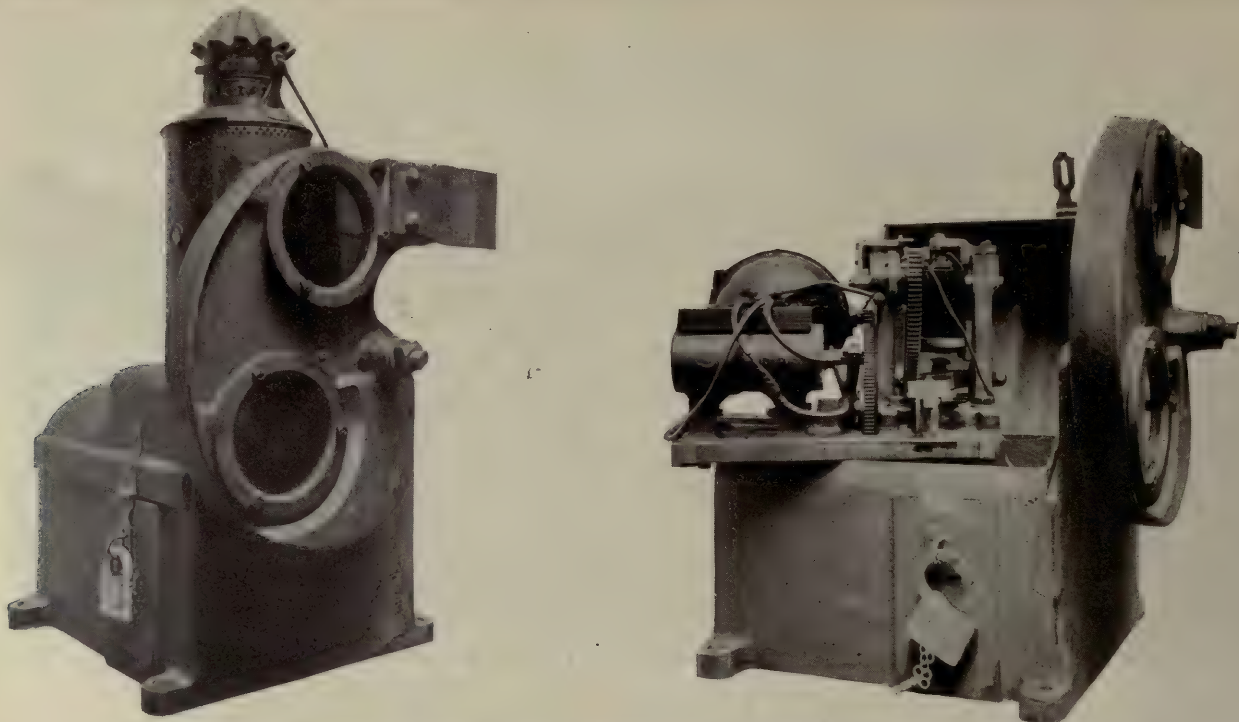
Fig. 1941. American Dwarf Signal at Electric Interlocking Plant.



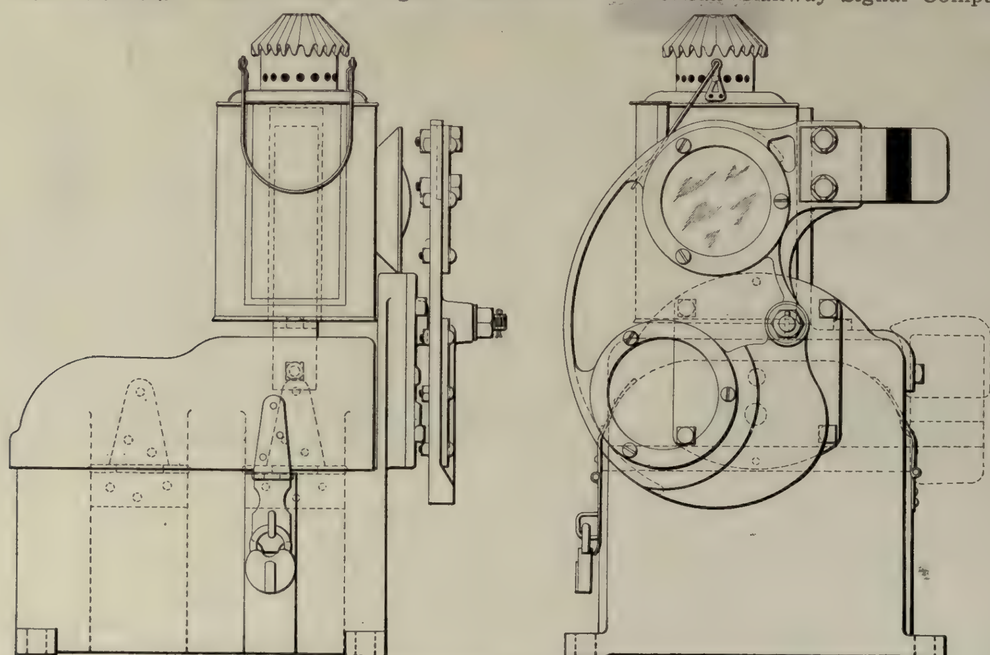
Figs. 1942-1943. Relays Used with Electric Interlocking, American Railway Signal Company.

Fig. 1944. Solenoid Dwarf Signal.

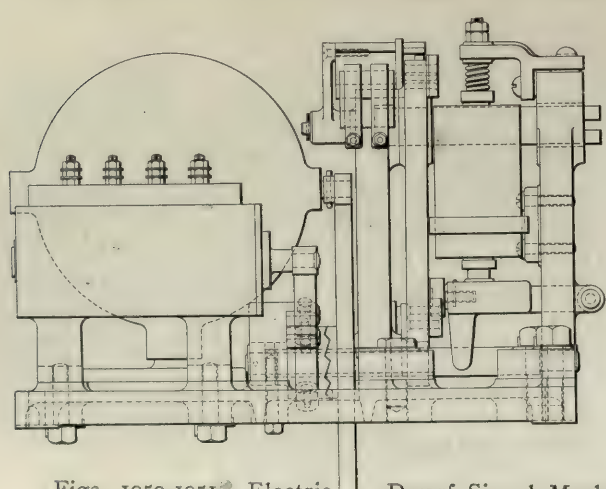
Fig. 1945. Hayes Derail and Switch Movement in Service. American Electric Interlocking.

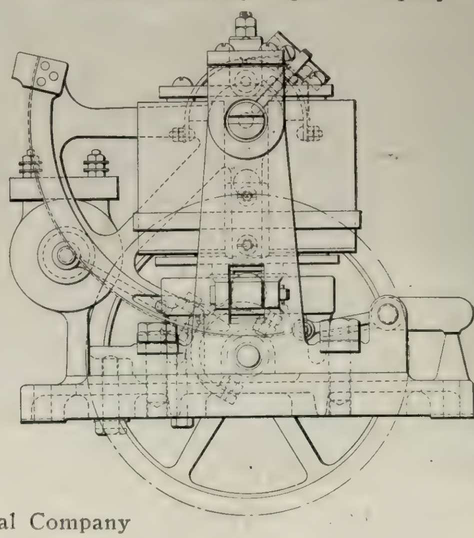


Figs. 1946-1947. Motor Dwarf Signal Mechanism. American Railway Signal Company.



Figs. 1948-1949. Electric Dwarf Signal (See Figs. 1946-1947.) American Railway Signal Company.





Figs. 1950-1951. Electric Dwarf Signal Mechanism (See Figs. 1946-1949). American Railway Signal Company

tacts 69, and through the motor in the right direction for the rotation required for the switch movement. Another part of the current passes through the pole changer coils 53, which coils control the pole changer box contacts. Still another part of the current passes through the coil of the clutch 34.

Fig. 1952. 54-Lever Electric Interlocking Machine Installed by American Railway Signal Company.

The current through this clutch causes the motor shafts 108 to be engaged with the operating shaft 80, through the gear set 18-19-44, and the turning of the motor rotates this operating shaft. The movement of the shaft 80 turns the cam 52, and the first movement of the cam engages the pin 97 of the lever arm 94 and moves it to its center position, where it remains

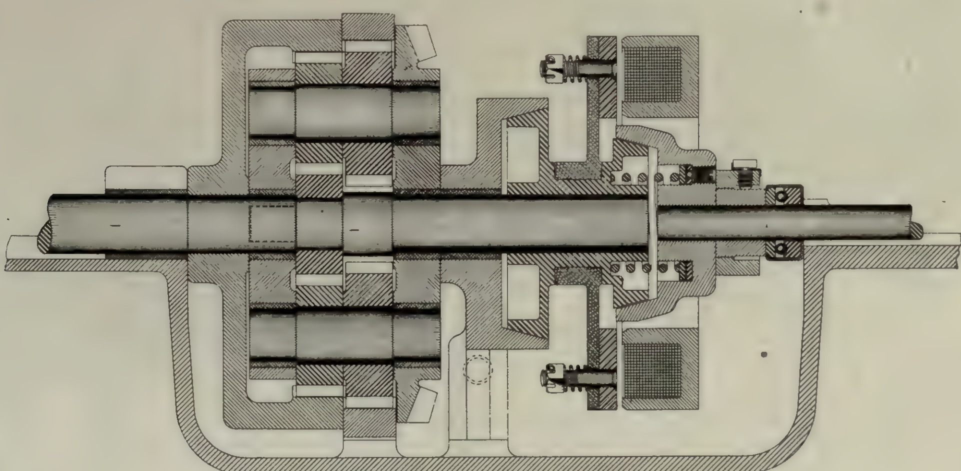


Fig. 1953. Clutch Magnet.

until the switch point has moved its full stroke. This lever arm 94 controls the detector bar, which is connected to the outer hole in the arm, moving the bar half way. The lever arm 94 also controls the plate 31, which carries the locking bolts 29. This locking plate moves one-half its stroke, withdrawing one bolt from the lock rod and setting the other bolt close to the rod ready for it to lock in the other position. When the locking bolts are withdrawn, the teeth in pinion 23 engage with the teeth in the rack 85 and cause the switchpoints to move over (see Fig. 1941). When the switchpoints are clear over, the second slope on the cam 52 again engages the pin in the lever arm 94 and moves the detector bar the remaining distance, also moving the plate 31 and causing the opposite bolt to enter the lock rod. The circuit controller box controls the indication circuit, the clutch circuit and also the circuits of the signal governing over the switch. This machine is so designed that it can be placed on the ties without cutting or framing any of them.

Fig. 1953 shows the clutch brake and gear set. The clutch coil 34 (Fig. 1939) is stationary, and, when energized, attracts the armature 35. The armature carries with it, through the springs 107, the disc 36, which drives the cone 32 into the shell this shell being keyed to the motor shaft. The cone 32 is keyed to the shaft of the gear set and, when the motor is turning with the clutch energized, drives the gear set through the cone and its shell. Shaft 80 is the main operating shaft. The rear of the clutch cone 32 carries another cone which is driven into the stationary shell 26 when the machine is stationary, this preventing any possibility of the machine being

operated by external means. The small spring serves to adjust the tension on the clutch.

The relay, Fig. 1942, is used in the operation of a signal. The normal position is, as shown, with both front and back contacts open. To operate the signal, the coil is first energized and then de-energized by the movement of the lever in the interlocking machine. This causes a plunger to be raised and dropped. The dropping of the plunger moves the armature into contact with the front points. Current then flows from the lever in the reverse position through one finger of the relay to the signal and back to the lever again through the other finger. When the signal is returning to the stop position, another coil is energized and de-energized, raising and dropping another plunger which moves the armature fingers into contact with the back points, through which position of the armature the indication is received after the signal has gone to stop. After the indication is completed, the armature fingers return to the neutral position.

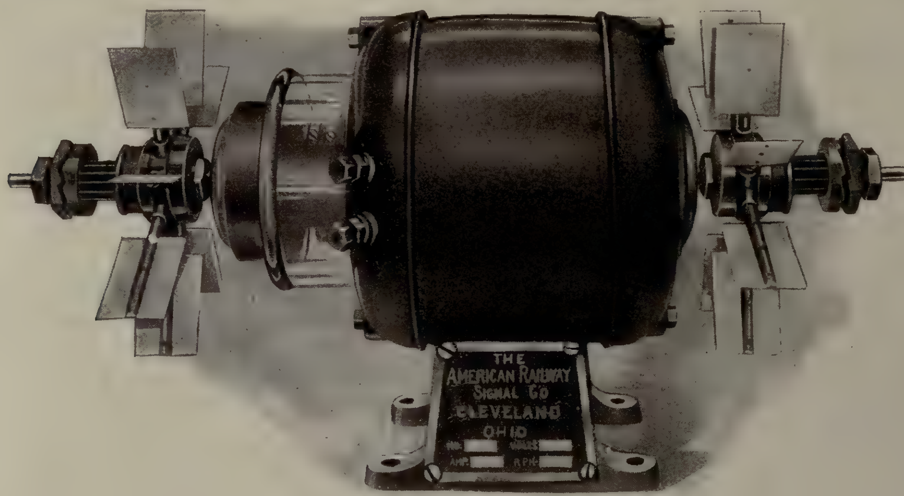


Fig. 1954. Motor for American Signal Mechanism.

ELECTRO-PNEUMATIC INTERLOCKING

THE UNION ELECTRO-PNEUMATIC INTERLOCKING.

In this system of interlocking, the operating power is supplied by means of air compressed at some convenient point, stored in one or more reservoirs and conveyed to each function by suitable pipe and hose connections. The control of this power is effected by means of electromagnets, the necessary electric current being obtained from any reliable source, such as primary or storage batteries or from a generator.

The ordinary air pressure used is 70 lbs. per sq. in., although the standard design of apparatus can be made to work satisfactorily with any pressure between 50 and 100 lbs. In order to avoid trouble from moisture condensing and freezing in the small air passages, the air on leaving the compressor is passed through a condenser consisting of a number of cooling pipes (see Fig. 2938) and a large percentage of the moisture is removed. Any remaining moisture is neutralized by alcohol, which is placed in the pipes and reservoir in freezing weather.

The air pressure acts on the piston of a cylinder fixed to the signal post or to the ties near the switch as the case may be. Near each cylinder is a small auxiliary reservoir to provide a sufficient supply of air to insure quick action of the piston at every operation.

The admission and exhaust of air at the cylinder is governed by electromagnetic valves, controlled through wires from the interlocking machine.

In the machine (Figs. 1955-1967) the levers are only a few inches long and very light, their principal work being to open and close electric circuits, and to operate the necessary mechanical locking between each other.

These levers appear as cranks on the front of the machine. Each lever has a latch by which it is held in any desired position, but this latch has nothing to do with the interlocking of one lever with another. Instead of pulling or pushing a lever the signalman turns it to the right or left, and operates a horizontal shaft which revolves on its axis through an arc of 60 deg. The shaft by means of a rack and pinion actuates miniature Saxby & Farmer locking, differing from that shown

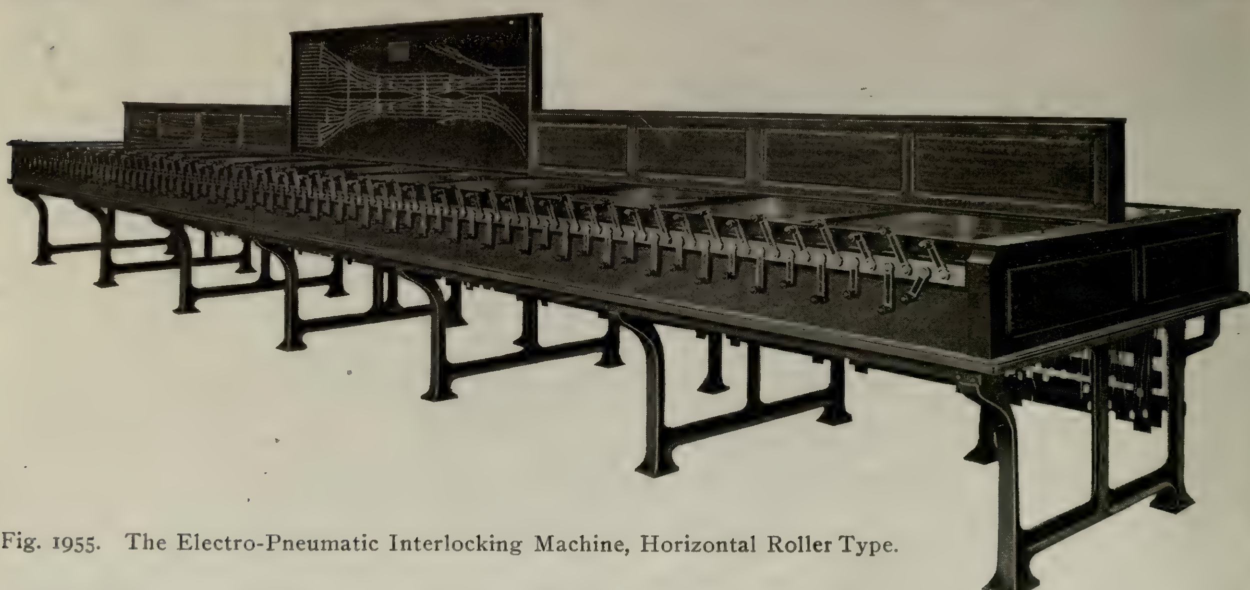


Fig. 1955. The Electro-Pneumatic Interlocking Machine, Horizontal Roller Type.

in Figs. 665-716 only in size and in the provision made for the movement of signal levers either to the right or to the left of the normal position.

The "indication" from a switch or signal actuates the armature of an electromagnet fixed in the machine, this armature engaging with suitable notches in a segment attached to the shaft of the lever. As arranged with switch levers, this magnet when de-energized locks the shaft after it has been turned far enough to move the switch, and prevents the signalman from completing the stroke of the lever until the switch has finished its movement and is locked in the new position. The indication being received, the stroke of the lever may be completed and (the necessary locking having thereby been released) the lever for the signal, giving a right to proceed over this switch, may be reversed.

To make clear the general principles governing switch and signal operation, Figs. 1968-1975 are presented. The operation of a signal will first be described. Fig. 1968 shows an ordinary lever of a mechanical type arranged to stand normally on center, which has attached to it a circuit controller that closes a circuit operating one signal when moved to the left, and closes a similar circuit for a second signal (conflicting in function with the first) when moved to the right. When the lever is normal, both signals are in the stop position and the lever is not engaged by the electric lock. When the lever is reversed to clear a signal, the latter, on leaving the stop position, opens the circuit controlling the lock which immediately engages the lever and prevents its complete return to normal, as illustrated in Fig. 1970. However, the lock permits of a partial return of the lever to normal (Fig. 1969), an amount insufficient to release such mechanical locking as is operated by it (not shown), and which must remain effective until the signal is actually in the stop position. This partial movement of the lever toward normal cuts off the current holding the signal in the proceed position and permits its return by gravity to the stop position. If for any reason it should fail to do so, it is obvious that the lever would be prevented from being put normal, and hence a change of route from the one governed by the deranged signal is prevented. A second lock similarly controlled by the signal in its extreme clear position might be added to detect failures of the signal to clear in response to its lever, but this is not considered necessary on account of the comparatively insignificant results of such a failure. The double reverse movement of the signal levers, besides forming a means of selecting and operating signals, also provides within itself an effective form of locking between two conflicting signals, since one lever cannot assume two positions at the same time.

In adapting the signal lever to the control of the four signals arranged, as shown in Fig. 1971, the wires operating the two opposing signals of Figs. 1968-1970 would be passed through a circuit controller or selector operated by the switch lever or by the switch itself, so that the direction of traffic would still remain under the control of the signal lever, but the signal operated for the route of a direction so selected would be determined by the position occupied by the switch at the time. This arrangement would necessitate extending the circuit of the signal lever lock to the control of the two additional signals, so that any one of the four being operated would produce the same effect on the lock as would either of the two signals of the arrangement shown in Figs. 1968-1970. This extension of the lock circuits is omitted from Fig. 1971 in order that the controlling circuit may be better understood. If we introduce other tracks and switches, and the necessary signals to govern movements from them over the switch shown in Fig. 1971, an extension of the selecting method may be made to include the operation from the same lever of all signals involved; but on condition that the track and traffic conditions never require but one signal to be operated at a time. When two or more signals may be operated simultaneously they, of course, require the use of as many levers. Figs. 1972-1975 show diagrammatically the arrangement of circuits and apparatus used for operating switches. The normal position of the lever is at the extreme left, as shown in Fig. 1972. The circuit controller C-N-L-R controls the circuits affecting the switch valve magnets, and normally current energizes valve magnet N, the other two magnets being de-energized. The effect of this condition is to retain air pressure against the side of the piston which holds the switch in its normal position. The armatures of the indication magnets N and R permit a partial movement of the lever from normal to reverse (that is, sufficient to shift the current from valve magnet N to valve

Fig. 1956. Cabin "A" Machine. P. T. & T. New York City. Union Switch & Signal Company.

magnets L and R), as indicated by dotted lines in Fig. 1972, the effect of which is to de-energize the former and to energize both of the latter. Valve magnet L (known as the lock magnet) is energized at the beginning of the stroke and before current is removed from N; this withdraws the lock controlled by magnet L which holds the switch valve in its normal position. The de-energizing of N and the energizing of magnet R follow immediately. This moves the "D-valve" (19, Fig. 2021), allows the air to escape from the normal side of the piston and admits air from the reservoir on the reverse side of the piston, moving it to the other end of the cylinder and reversing the switch. This partial reversal of the lever can (through the usual mechanical locking provided between switch and signal levers) be made only when all signals, governing movements over the switch to be operated, are in the stop comes locked in its reversed position; current is also cut off from the indication magnet R and its latch released.

Under the tappet engaged by the latches of the indication magnets is shown a circuit shifter, known as the "quick switch," controlling these magnets. It is moved by the tappet only after the latter has been released and after the lever has been put into one or the other of its extreme positions. This arrangement is designed to prevent any other than that magnet which corresponds with the position of the switch desired being in circuit at any time (a precaution designed to guard against false indications resulting when the switch is momentarily in one position and the lever is in a semi-reversed position tending to shift it to the other.)

The same conditions govern the return of the switch and its lever to normal; but the other pair of indication contacts, N

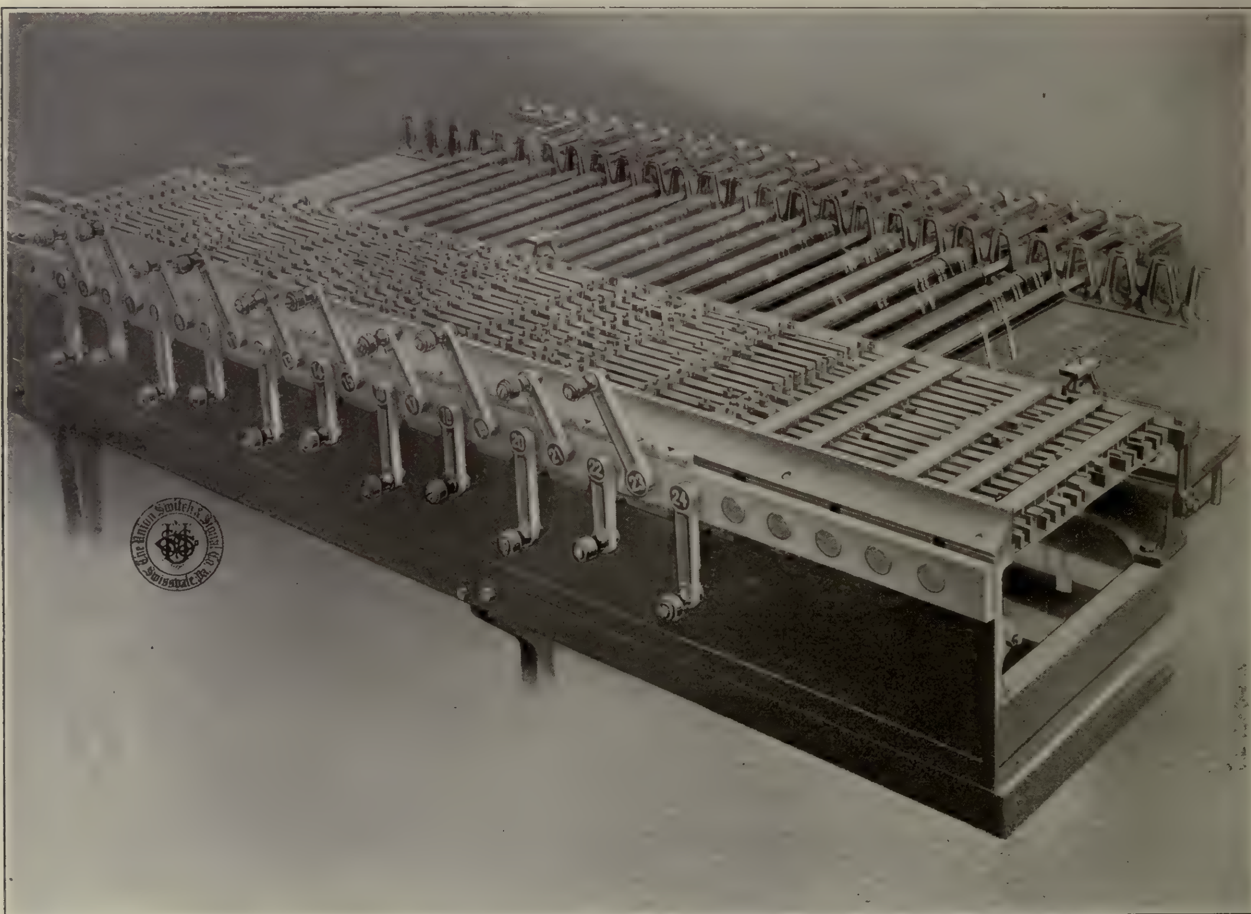


Fig. 1957. Electro-Pneumatic Interlocking Machine; View from Front Showing Locking, Combination Plate and Indication Segments.

position and when so moved it retains locked all such signals until its complete reversal is effected. Mounted over the switch and lock movement are two pairs of contact springs so arranged that one pair is closed by the slide bar in its extreme normal position (Fig. 1972) and the other pair closed in its extreme reverse position (Fig. 1973). Both pairs of these contacts are open unless the switch is locked in either one position or the other. When the complete movement of the switch is effected and the lock of the switch movement has secured the switch in its reversed position, the plate P is shifted by the movement into contact with springs, R, R. The effect of the circuit thus established on the indication magnet R at the machine (which circuit is formed in part by the wire extending from the machine to the lock magnet L, largely for the sake of economy in wires and for convenience of arrangement) is to energize this magnet, and thereby to lift its armature from longer obstructing the movement of the lever to its extreme reversed position (Fig. 1973). The final movement of the lever may then be made, which releases the mechanical locking that was heretofore in effect, preventing signals from being cleared for movements over the switch, and at the same time shifts the switch controlling contacts to the position shown in Fig. 1974, the effect of which is to remove at once the current from the valve lock magnet, whereupon the switch valve be- and N, on the switch movement, and the other indication magnet, N, engaging the lever, are brought into use for this purpose. When more than one switch is operated by a single lever, as in the case of a cross-over, the normal and reverse valve magnets at one switch are in series with their corresponding magnets at the other switch, the lock magnets are in multiple, and the indication contacts in series, as shown in Fig. 1971, an extension of the selecting method may be made of the two contacts thus included in the indication circuit closes as its own switch becomes fully moved and locked (this being the case whether these operations occur simultaneously or not), but no indication will be received at the machine unless both switches are locked in the desired position.

The signal used is a semaphore, Figs. 1980-1981, the design being the same used both for interlocking and for block signaling, and is shown in Figs. 594-600. Figs. 1978-1979 show a mechanism designed to operate two arms in three positions, and one arm in two positions. The arrangement shown is for use on a signal bridge where the two-position arm is below the mechanism and operated by the rod extending downward. The three-position arms are situated above the mechanism and operated by the rods extending upward, one for each arm. Each of these rods is provided with two cylinders, as may be seen in Fig. 1978. When air is admitted to one cylinder its

piston is raised, raising one rack which moves a pinion through half its travel in the same manner as with the three-position Style "B" motor signal shown in Fig. 538, causing the arm to assume its intermediate or "caution" position. When the second piston is raised the pinion is again moved upward, completing the movement of the arm to the clear position. The arm to the stop position is secured by the use of the spring 8, instead of by a weight such as is used in the high semaphore. The cylinder is movable and the piston stationary, the air pressure pushing up the cylinder against the downward pressure of the spring. This movement causes the arm to assume the clear position, and on the release of the air, when

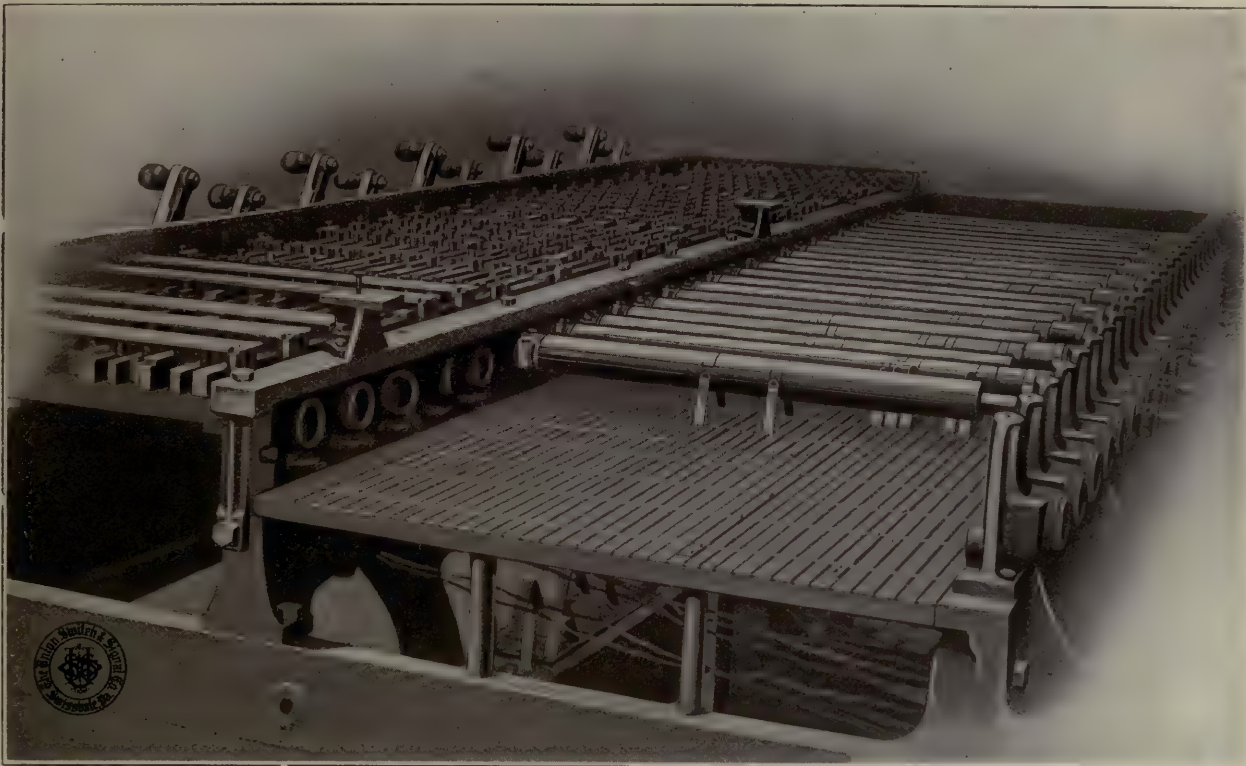


Fig. 1958. Electro-Pneumatic Interlocking Machine, Horizontal Roller Type; View Showing Side Elevation.

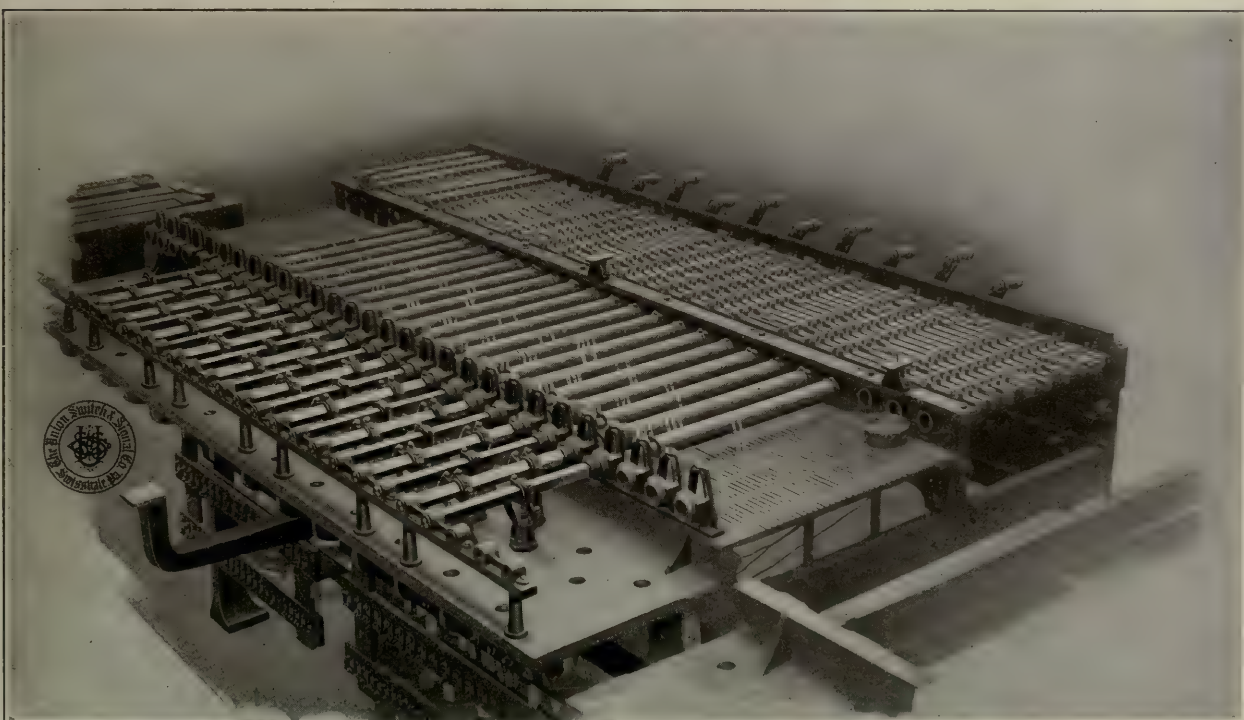


Fig. 1959. Electro-Pneumatic Interlocking Machine; View from Rear Showing Locking, Combination Plate and Indication Segments.

mechanism may be provided with special piping so that the air supply for the third position passes through the second position valve. Circuit controllers attached to hard rubber cylinders may be seen at each side of the mechanism in Fig. 1978.

In the dwarf semaphore (Figs. 1985-1986) the return of the the signal is to be restored to the stop position, the spring forces the cylinder and connecting rod downward. The piston rod is hollow, thus serving as a port for the admission of air to the cylinder and also for exhaust. If the spring should fail to restore the signal to the stop position, the signal lever would be held by the indication lock, preventing its full return

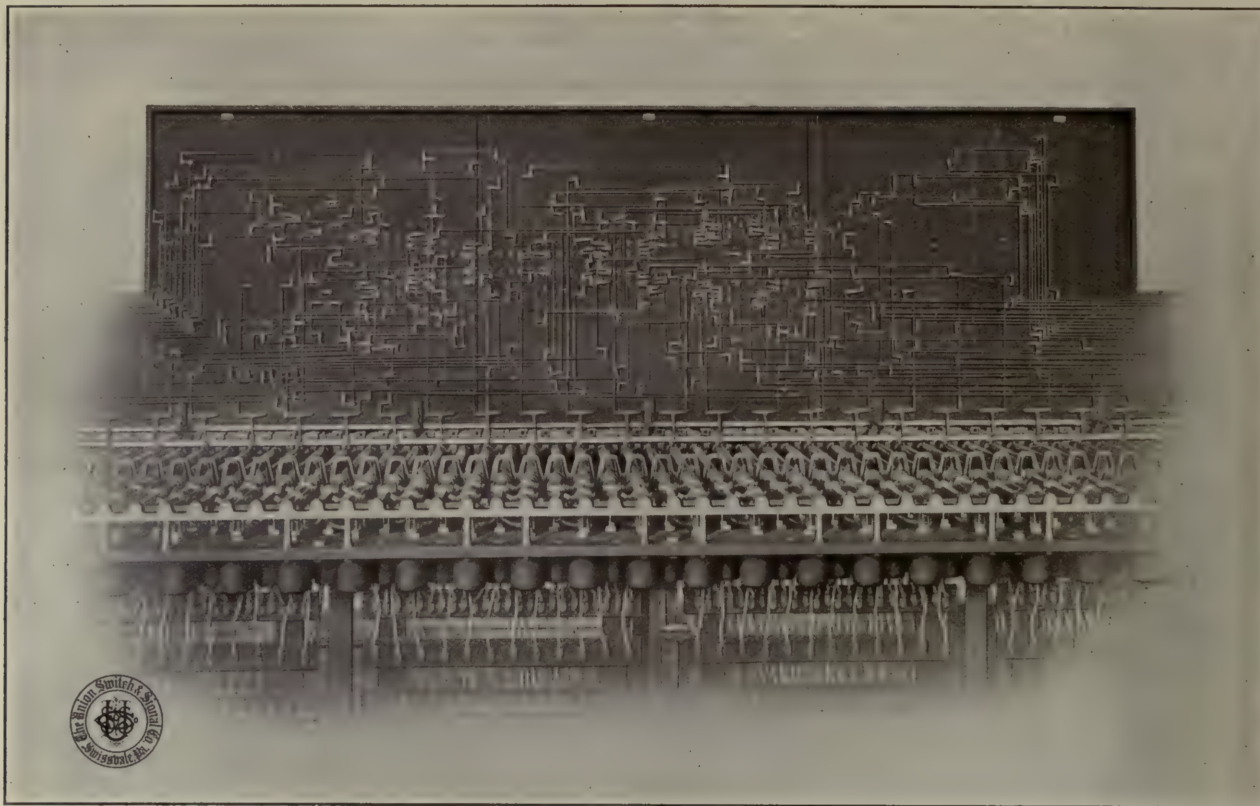


Fig. 1960. Electro-Pneumatic Interlocking Machine; Rear View of Track Model.

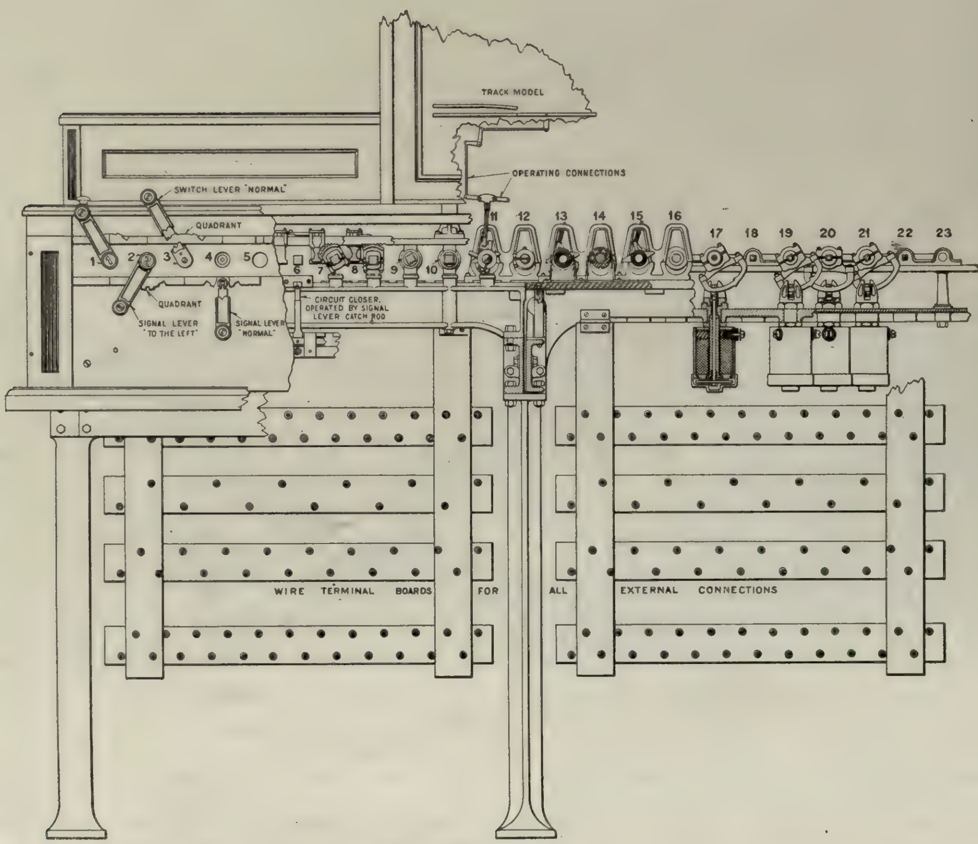


Fig. 1961. Electro-Pneumatic Interlocking Machine; Front Elevation Partly in Section.

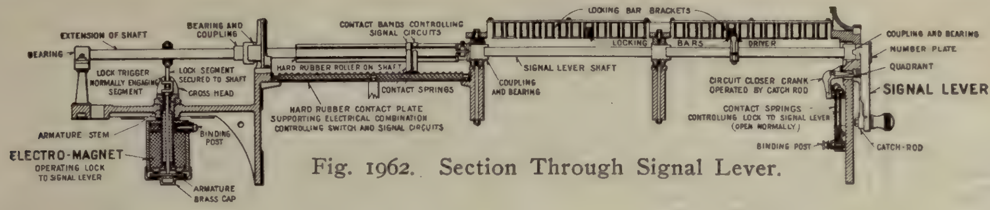


Fig. 1962. Section Through Signal Lever.

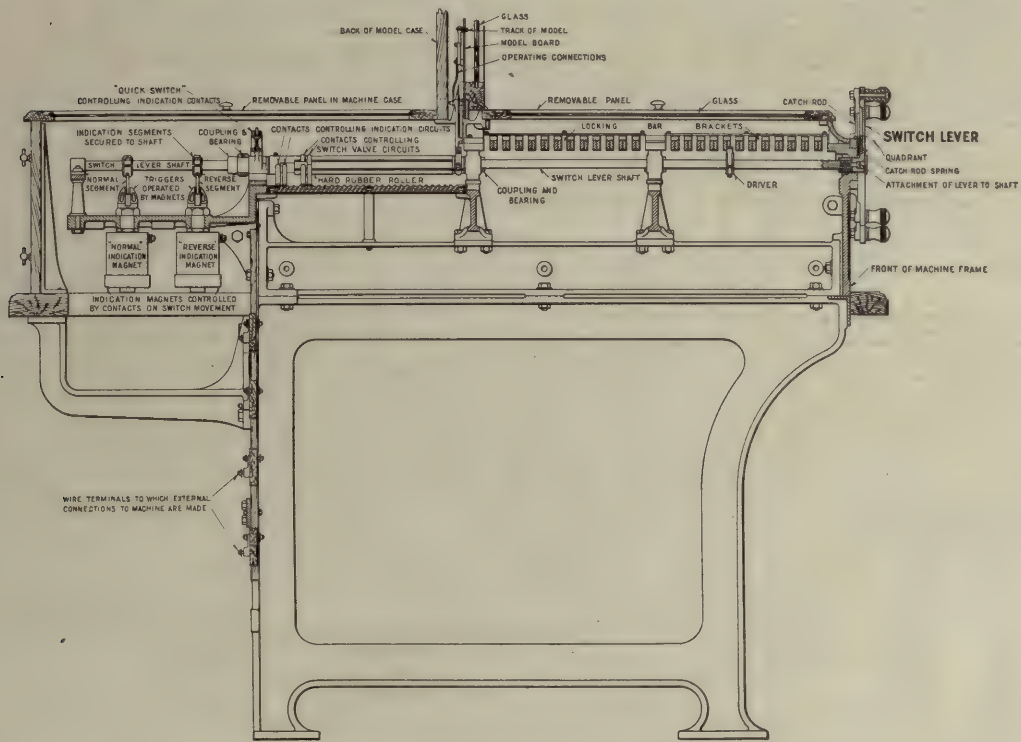


Fig. 1963. Section Through Switch Lever.

Figs. 1962-1963. Sectional Views of Electro-Pneumatic Interlocking Machine.

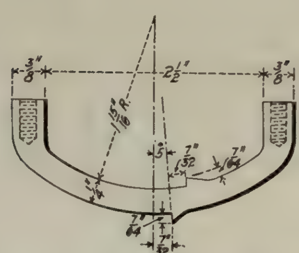


Fig. 1964. Indication Segment for Switch Lever.

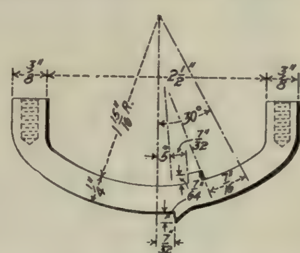


Fig. 1966. Indication Segment for Signal Lever.

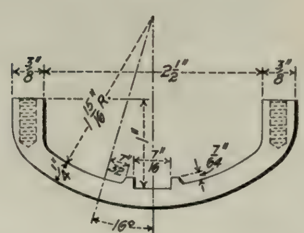


Fig. 1965. Indication Segment for Switch Lever, with Electric Detector Circuits.

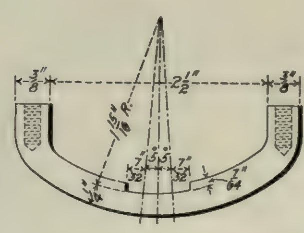


Fig. 1967. Indication Segment for Traffic Lever (Check Locking).

to the normal position, thus compelling attention to the defect in the signal. The indication contacts are closed by a metal strip (27, Fig. 1986) mounted on an insulated contact block attached to the cylinder. Thus the indication circuit is open unless the arm is in the stop position.

Figs. 1995-1996 show a suspended semaphore arm operated

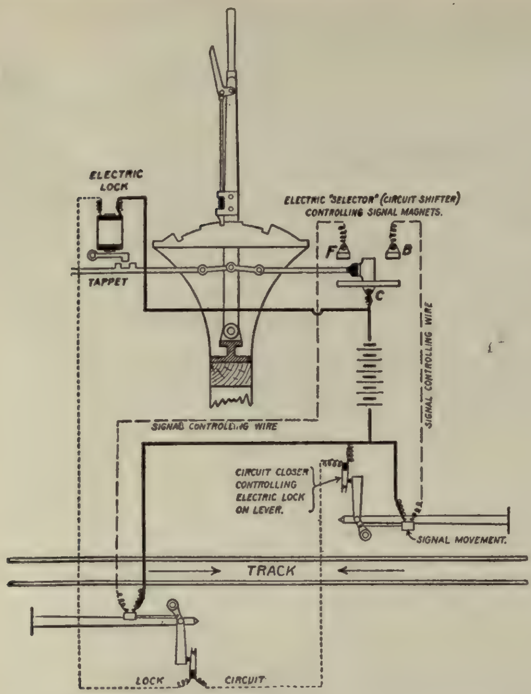


Fig. 1968. Signal Lever in Normal Position; Signals at Stop; Lever Free to Clear Either Signal.

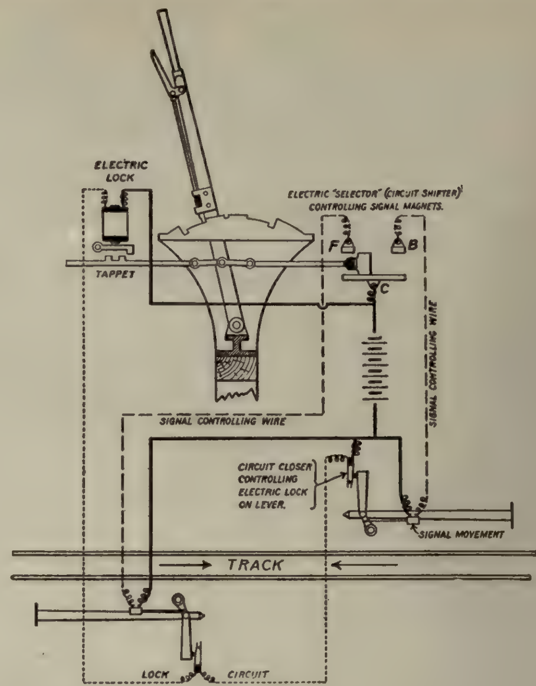


Fig. 1969. Signal Lever Reversed to the Left; One Signal at Proceed; Signal Lever Locked, Preventing Full Movement to Normal.

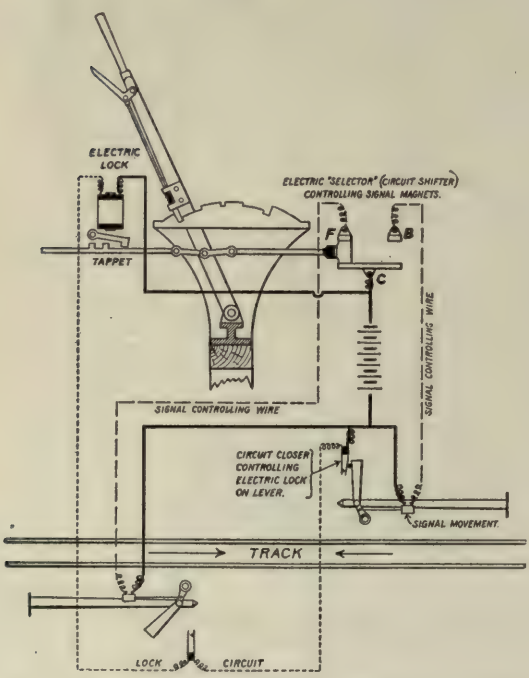


Fig. 1970. Signal Lever in "Half-Reverse" Position. Signals at Stop; Lever Free to Complete Movement to Normal.

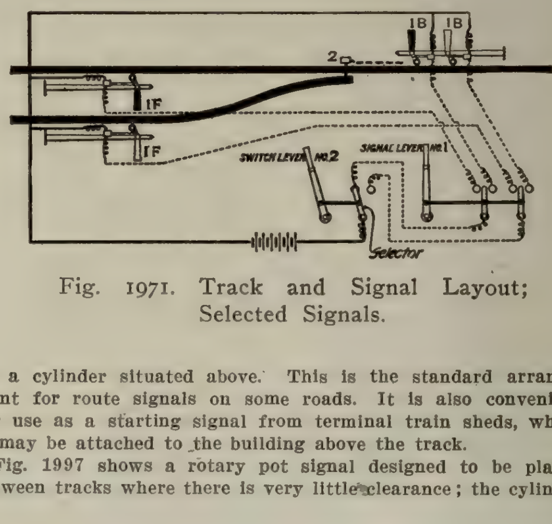


Fig. 1971. Track and Signal Layout; Selected Signals.

by a cylinder situated above. This is the standard arrangement for route signals on some roads. It is also convenient for use as a starting signal from terminal train sheds, where it may be attached to the building above the track.

Fig. 1997 shows a rotary pot signal designed to be placed between tracks where there is very little clearance; the cylinder

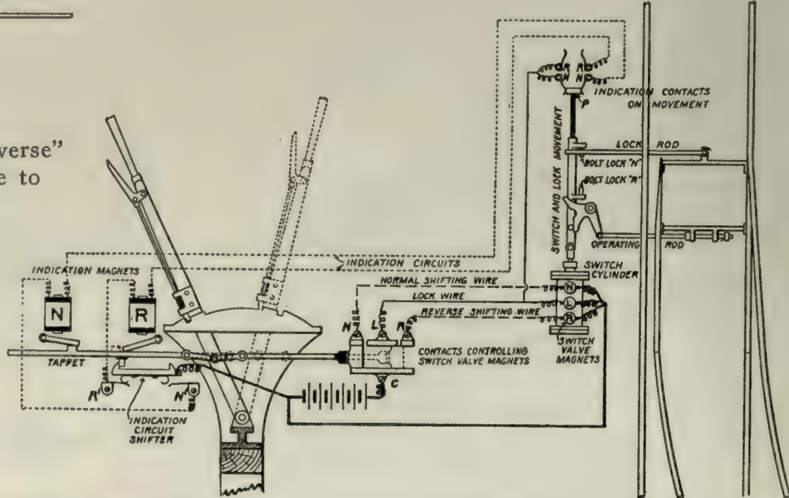


Fig. 1972. Switch Lever in Normal Position; Dotted Lines Show Preliminary Movement Made by Lever in Reversing the Switch; Switch Has Not Started to Move.

is placed in a horizontal position and moves the lamp and disks by a crank. They are restored to the stop position by the spring operating under the same conditions as in the dwarf signal.

Portions of the electro-pneumatic interlocking machine are shown in Figs. 1957-1967, Figs. 1962-1963 being a section from back to front. The track model, a feature of this machine, appears in section in the upper part of Figs. 1961 and 1965. locking parts, supported by the locking bar brackets, are similar in design to the interlocking shown in Figs. 794-845. The whole apparatus is inclosed in a wooden case with glass top. The wire connections (not shown in the drawings), are all run to binding posts on the rear of the frame supporting the machine.

The process of operating a switch lever may be briefly described as follows, taking, for example, lever No. 3, Fig. 1961.

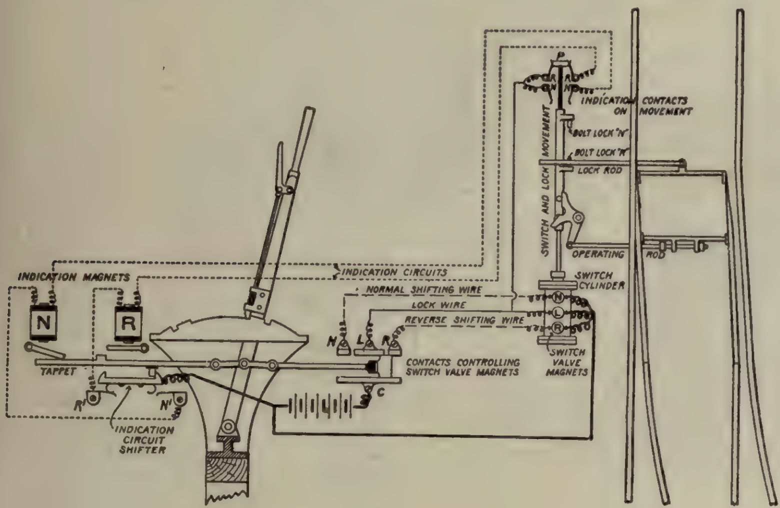


Fig. 1973. Switch Lever Against Reverse Indication Stop; Switch Has Moved and Become Locked in Reverse Position; Lever Has Been Released by Indication Lock for Final Movement to Full Reverse Position.

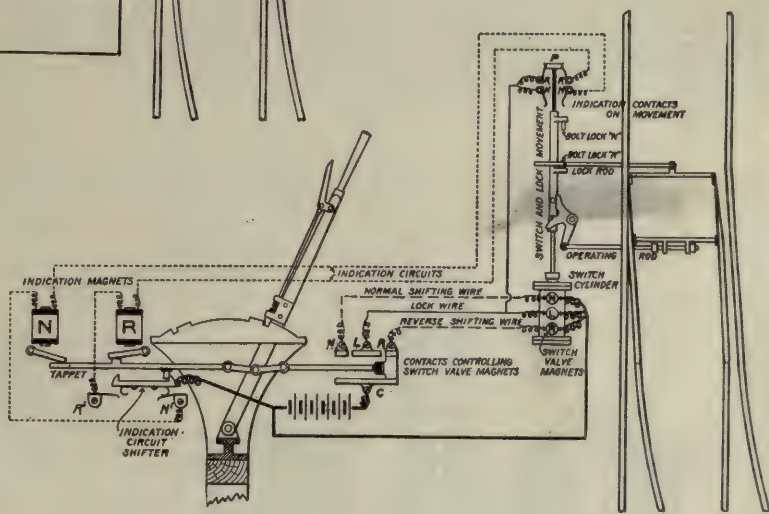


Fig. 1974. Switch Lever in Reverse Position; Indication Latch Released; "Quick Switch" in Position to Receive Normal Indication.

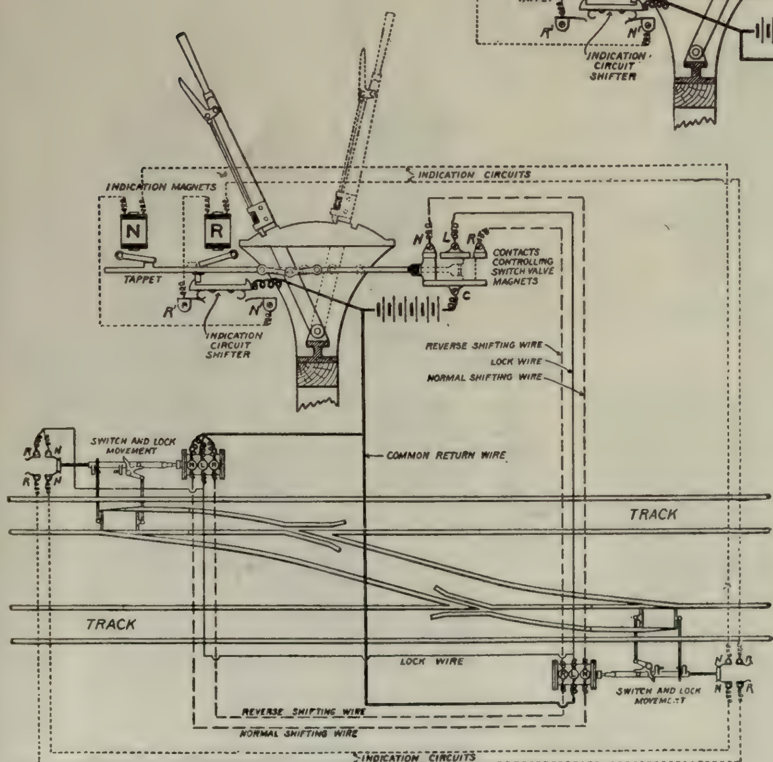
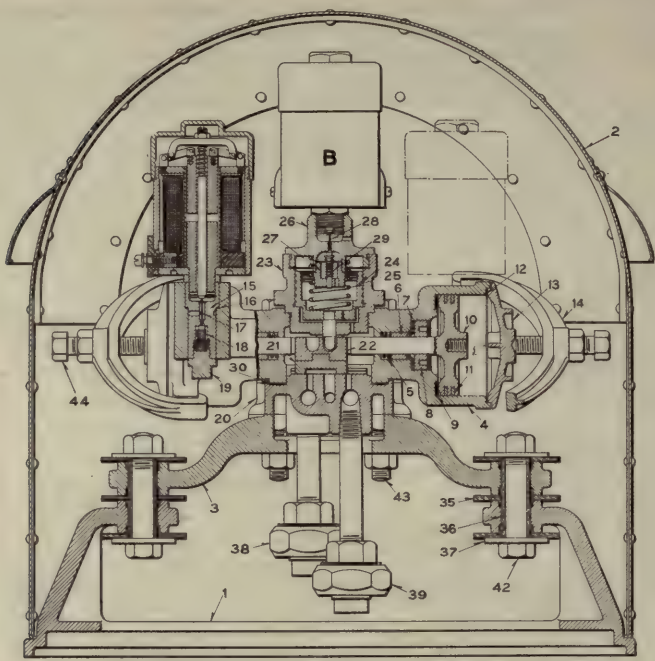


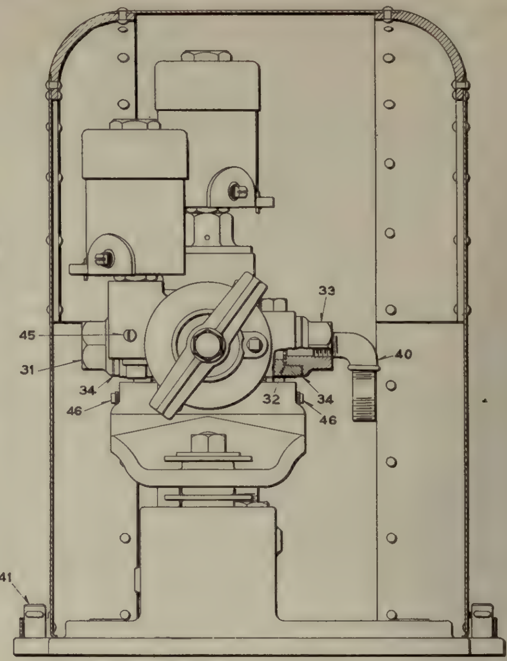
Fig. 1975. Switch Lever and Connections Arranged to Operate a Crossover.

It consists of metal strips representing a plan of the track. Each portion which represents a switch is movable, and is connected to the switch levers in such a way that every movement of the lever to move a switch in the track moves the corresponding part of the model (see Fig. 1960). Some models have miniature signals as well as tracks.

The principal parts of the interlocking machine are indicated in the transverse section, Fig. 1961. The mechanical inter- All signals which could give a clear route over the switch in its present position being in the stop position, so that the interlocking will not interfere with the intended movement, the signalman moves the lever to the right, revolving the shaft. As soon as this revolution has begun the driver on the shaft (see Figs. 1962-1963) has moved the locking bar a short distance, so as to lock all levers which, if moved, would permit trains to interfere with the intended movement. This locking



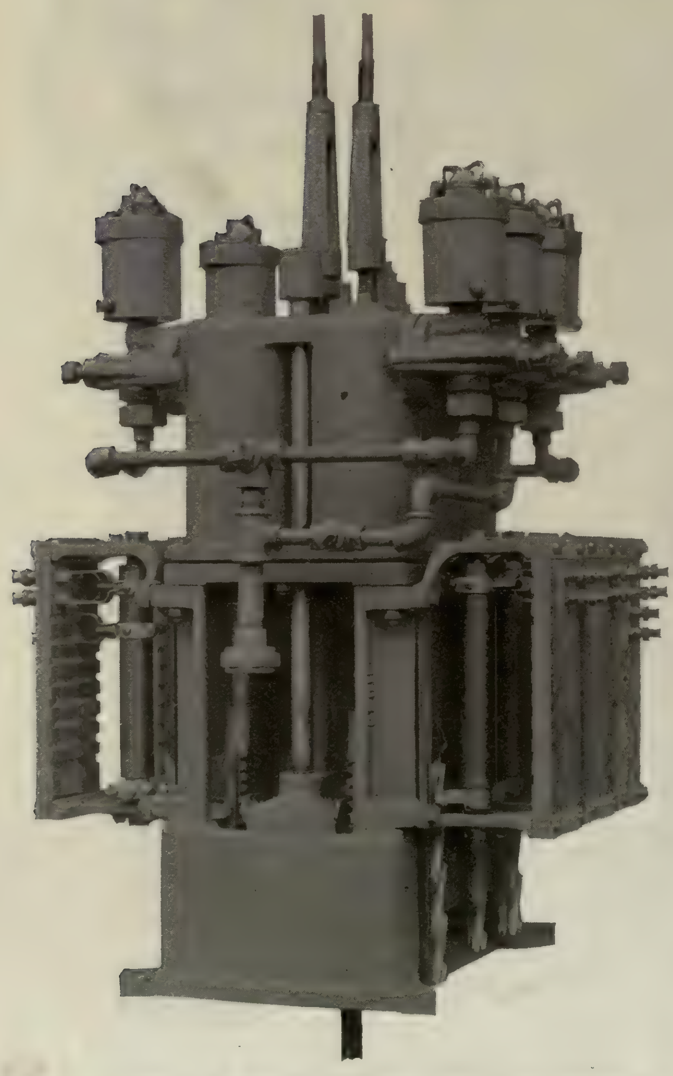
SECTIONAL SIDE VIEW

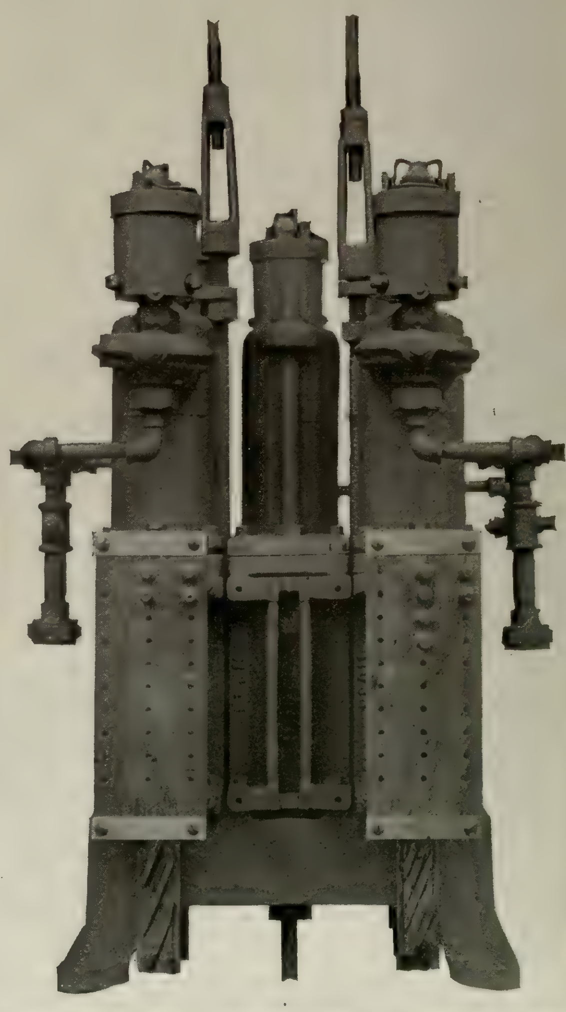


END VIEW
COVER SECTIONED

A

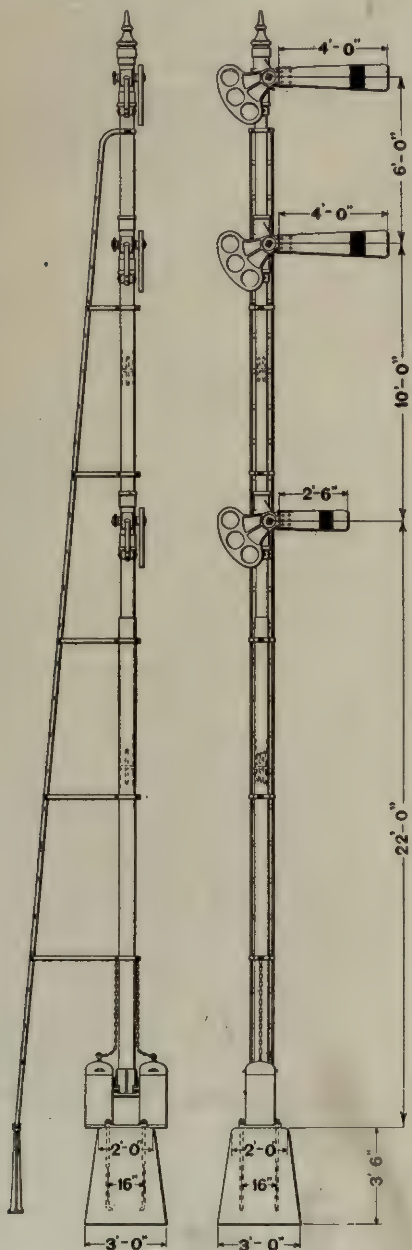
Figs. 1976-1977. Electro-Pneumatic Switch Valve Mounted Independent of Cylinder.





Figs. 1978-1979. Electro-Pneumatic Signal Mechanism for Operating Two Arms Above in Three Positions, and One Arm Below in Two Positions. Pennsylvania Railroad.

effected, the further revolution of the shaft causes bronze strips to close the switch valve circuits, which admit air to the switch cylinder. The piston movement produced by this air pressure unlocks the switch, moves it to the other position, and then locks it. The locking of the switch having been completed, the closing of the contact in the indication box energizes its proper indication magnet in the machine, and the signalman is then able to complete the stroke of his lever, leaving it inclined to the right. This final movement pushes the locking bar the remainder of its stroke and unlocks the lever or levers by which the signalman will clear the signal to permit a train to pass over the switch in its new position.



Figs. 1980-1981. Three-Arm Electro-Pneumatic Signal. Pennsylvania Railroad.

The switch cylinder is shown in Fig. 1999. Each cylinder, by means of its piston, moves the switch, detector bar and lock; also two or more switches near together may be moved by the same cylinder where it is found desirable to do so (see Fig. 1998). This multiplication of functions is provided for by an increase in the size of the cylinder or by a higher air pressure.

In Figs. 1998-1999 and 2017-2019 is shown the movement by which the rod from the cylinder performs the double function of moving the switch and locking it. This device is similar in principle to the locking apparatus used with other kinds of interlocking where such a combination of functions is desired. The principal parts are so lettered as to explain their use. The flexible connection from the auxiliary reservoir to the cylinder is employed to provide against undue strain on the pipe connections on account of settling of the different parts. The piston rod and the slide bar of the switch and lock movement, together with the detector bar connection, are permanently connected and may be treated as a single rod. This rod has a stroke of eight in.; but its action on the switch, by means of the escapement crank, does not begin until it has moved about two in.; and the switch action is finished in the next four in. of the movement; so that the first two in. can be used to unlock the switch and the last

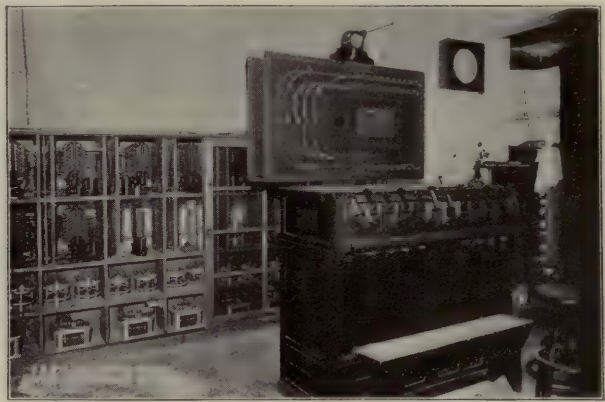


Fig. 1982. Hudson & Manhattan Interlocking Tower in Church Street Terminal.

two in. to lock it in its new position. The lock rod, where it passes through the frame, appears in elevation, as in Fig. 2020. The slide unlocks the switch by withdrawing a lug from the lower notch *y* (which lug is indicated in Fig. 2017 by dotted lines), and locks the switch after moving it (and changing the position of the lock rod) by pushing another lug into the upper notch *x*. The vertical pin in the slide bar which moves the escapement crank is fitted with a loose collar.

Figs. 2021-2022 show the details of the switch valve. The admission and exhaust of air to and from the cylinder is controlled by the D-valve 19, in the same manner as is done by the ordinary slide valve of a steam engine. This valve is operated by two small pistons, one on each side, which are in

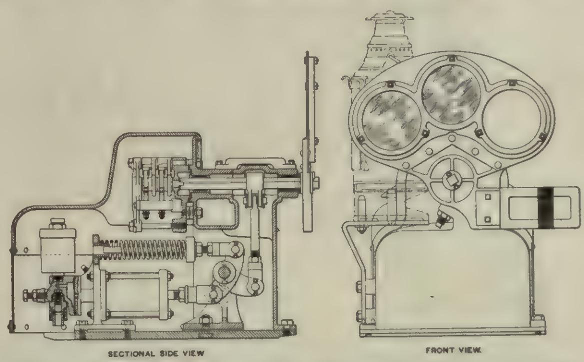
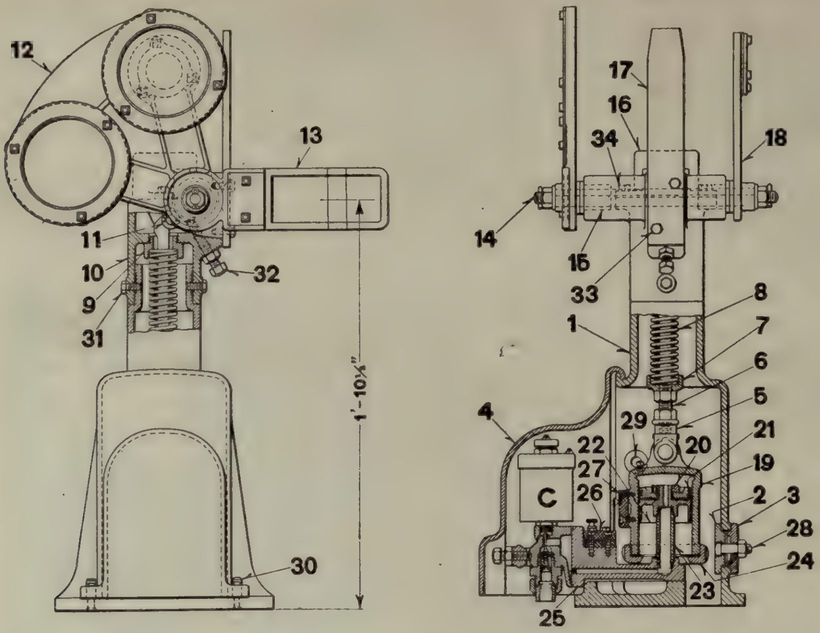


Fig. 1983-1984. Three-Position Electro-Pneumatic Dwarf Signal. Upper Quadrant Indication, Having One Cylinder for Each Position.

turn controlled by the pin valves of the normal and reverse magnets, the same as in the signal mechanism, explained in connection with Fig. 597. The lock magnet in the center controls a bolt which engages the D-valve in each of its extreme positions. When the magnet is energized the spring 16 is compressed and the bolt withdrawn, allowing the D-valve to be moved. Thus it is necessary to have one magnet de-energized and the other two energized before the switch will be moved.

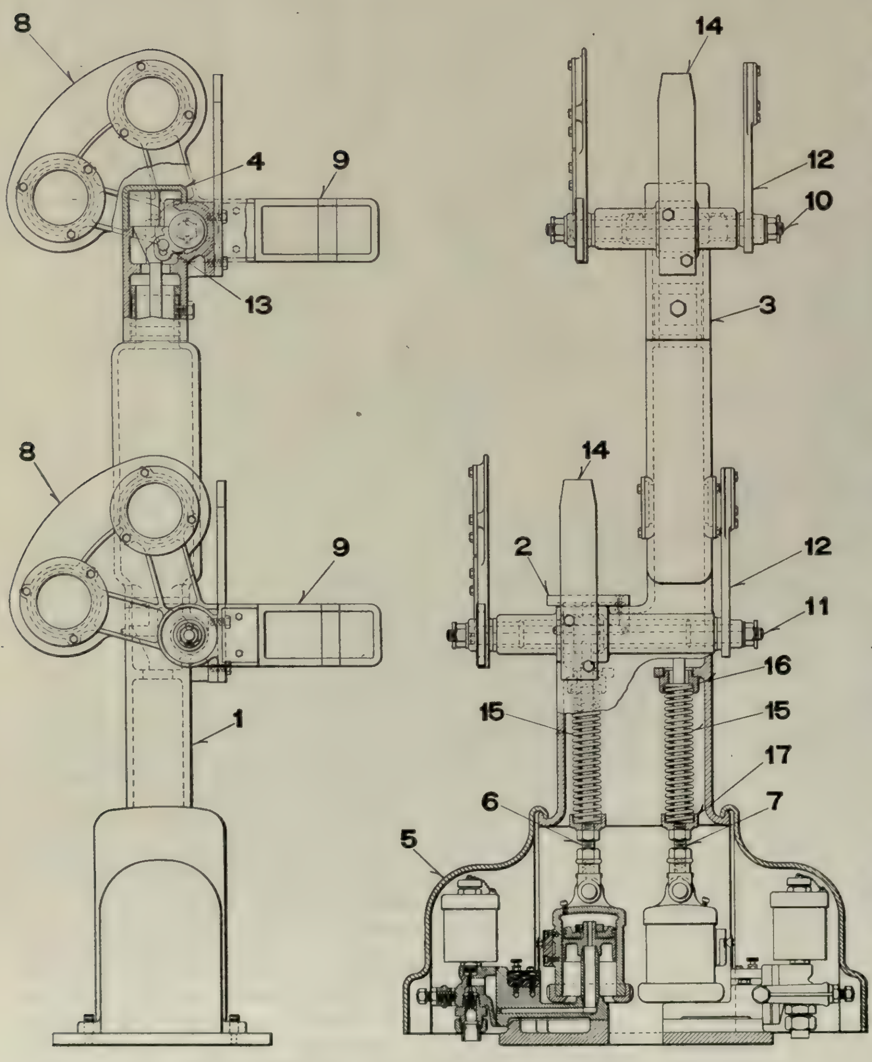
For the Subway Division of the Interborough Rapid Transit Co., owing to the restricted clearances, it was found necessary to redesign some of the electro-pneumatic interlocking apparatus. It was necessary to mount the controlling valve magnets for the switch cylinders on the cylinder head and also to design a motion plate switch and lock movement. In some cases, also, the switch valves were mounted on a separate base several feet away from the cylinder. The special switch



Figs. 1985-1986. One-Arm Electro-Pneumatic Dwarf Signal.

Names of Parts of One-Arm Electro-Pneumatic Dwarf Signal; Figs. 1985-1986.

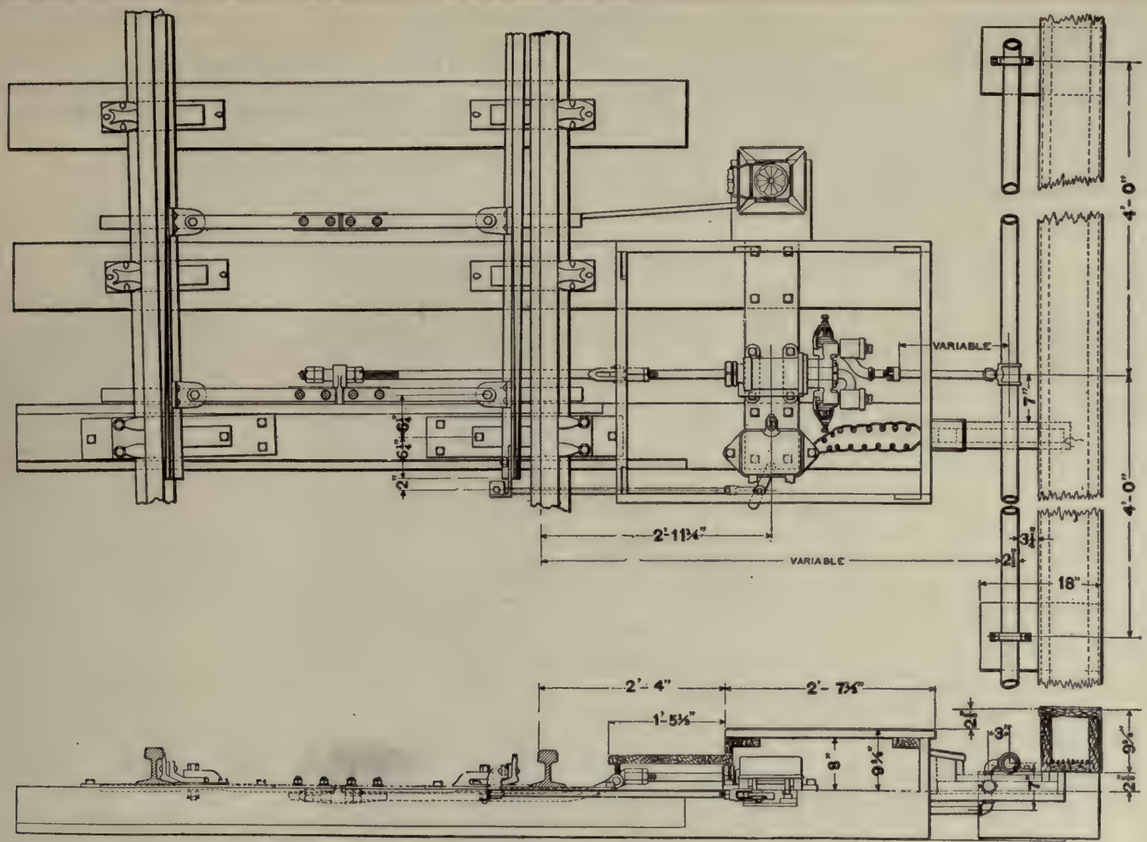
1 *Post and Base*
2 *Inside Plug for Opening for Mechanical Connection*
3 *Outside Plug for Opening for Mechanical Connection*
4 *Mechanism Cover*
6 *Up and Down Rod*
7 *Bottom Spring Socket*
8 *Restoring Spring*
9 *Top Spring Socket*
10 *Semaphore Bearing*
11 *Semaphore Crank*
12 *Spectacle, 60°*
13 *Blade*
14 *Semaphore Shaft*
15 *Journal for 14*
16 *Cap*
17 *Lamp Bracket*
18 *Back Spectacle*
19 *Cylinder*
20 *Nut for Fastening Piston Ring Cage*
21 *Cage for Piston Rings*
22 *Piston*
23 *Hollow Piston Rod and Air Inlet*
24 *Cylinder Cap*
25 *Valve Base*
26 *Circuit Breaker Springs and Base*
27 *Contact Block and Strip*
28 *Bolt for 2 and 3*
29 *Hole for Crank Pin*
30 *Dowel Pins*
31 *Cap Screw*
32 *Semaphore Adjusting Screw*
33 *Tap Bolt*
34 *Screw for Cap*
C *Pin Valve Magnet*



Figs. 1987-1988. Two-Arm Electro-Pneumatic Dwarf Signal.

Name of Parts of Two-Arm Electro-Pneumatic Dwarf Signal; Figs. 1987-1988.

1 *Post and Base*
2 *Cap for Lower Semaphore Bearing*
3 *Semaphore Bearing*
4 *Cap for Upper Semaphore Bearing*
5 *Mechanism Cover*
6 *Up and Down Rod, Lower Arm*
7 *Up and Down Rod, Upper Arm*
8 *Spectacle, 60°*
9 *Blade*
10 *Semaphore Shaft, Upper Arm*
11 *Semaphore Shaft, Lower Arm*
12 *Back Spectacle*
13 *Semaphore Crank*
14 *Lamp Bracket*
15 *Restoring Spring*
16 *Top Spring Socket*
17 *Bottom Spring Socket*



Figs. 1989-1990. Direct Acting Electro-Pneumatic Switch Movement Layout for Single Switch Without Detector Bar.

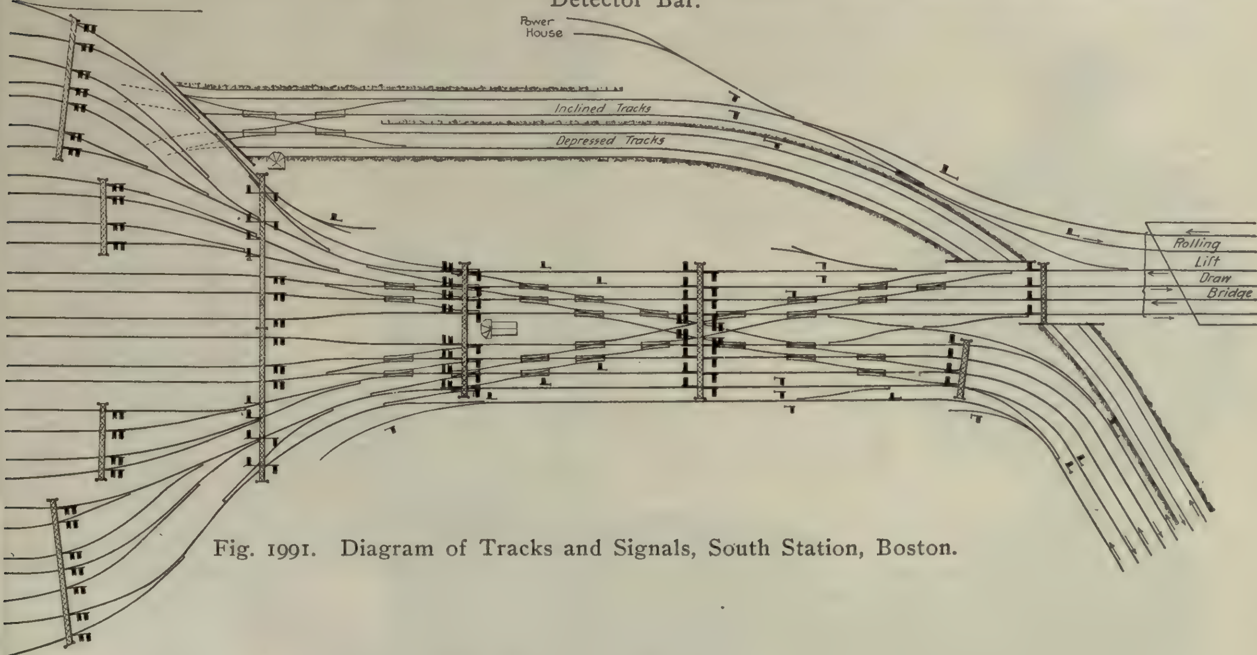
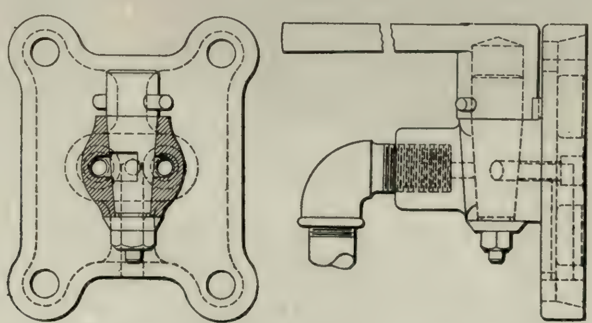


Fig. 1991. Diagram of Tracks and Signals, South Station, Boston.



Figs. 1992-1993. Three-Way Valve, Used for Operating Electro-Pneumatic Switches by Hand During Installation of Plants Under Traffic.

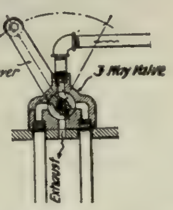
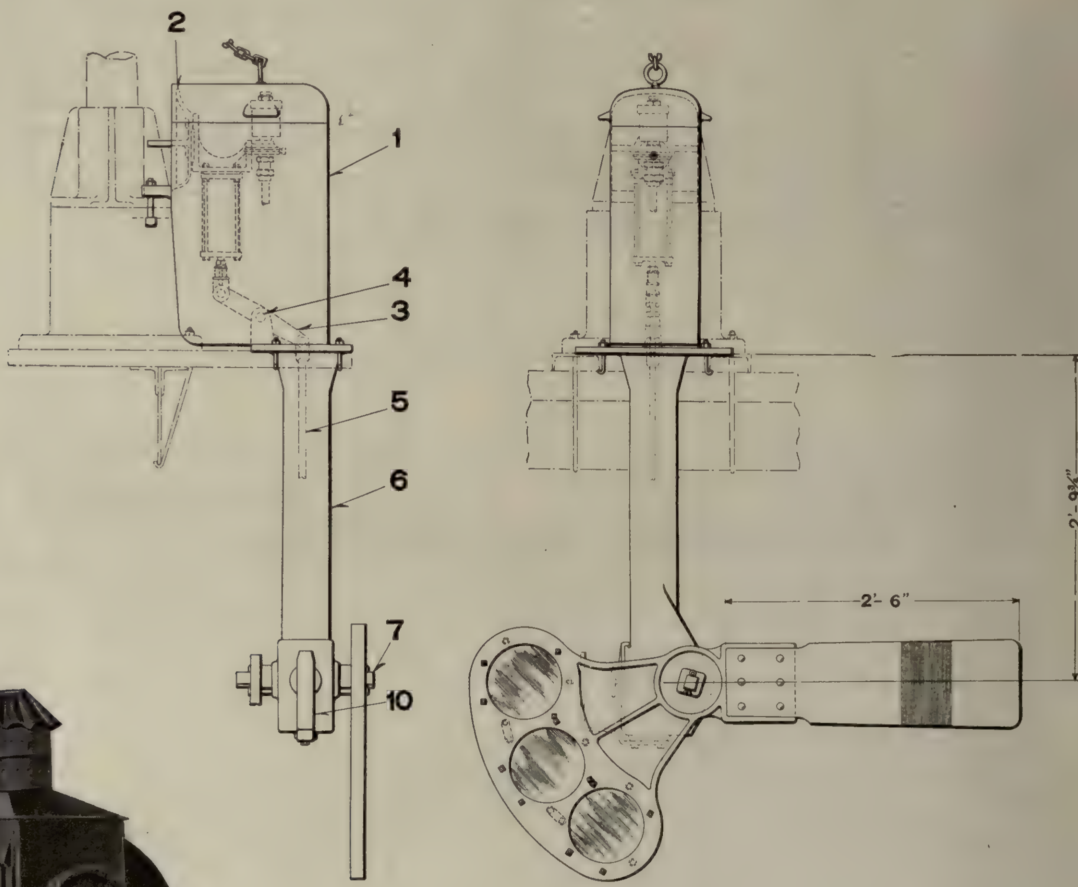


Fig. 1994. Diagram Showing Operation of Valve Shown in Figs. 1992-1993.

and lock movement is shown in Figs. 2006-2008. It was found that in many cases there was not sufficient space to install the electro-pneumatic interlocking machine with horizontal rollers as usually made. A machine was therefore designed with vertical rollers. Figs. 2023-2024, which is very compact. The interlocking signals used in the subway are of the same design as those used for block signaling shown in Figs. 689-692. The dwarf signal is shown in Fig. 2025.

Figs. 2026-2028 show what is known as the push button electro-pneumatic interlocking machine. This is employed like the dwarf interlocking machine where a number of switches are concentrated in a yard where all the movements are low speed and no interlocking is required between levers, the machine being employed merely to reduce the number of men necessary to operate the switch. This machine is so arranged that pressing of one button will reverse the switch, and pressing of another button will put it normal again. Figs. 1989-1990 show a switch arranged to be used with this type of machine, and the circuits for operating it are shown in Fig. 2003, which also shows a track circuit and electric lock used in place of a detector bar.* The switchbox is a pole changer and the electric lock is polarized.

Fig. 1991 is a diagram of the tracks and signals at the South Terminal Station, Boston, which are operated by the machine shown in Fig. 1955.



Figs. 1995-1996. One-Arm Electro-Pneumatic Suspended Route Signal.

Names of Parts of Suspended Electro-Pneumatic Signal;
Figs. 1995-1996.

1 *Cover*
2 *Cylinder Bracket*
3 *Lever*
4 *Shaft with Cotters*
5 *Up and Down Rod*
6 *Post*
7 *Semaphore Shaft*
10 *Lamp Bracket*

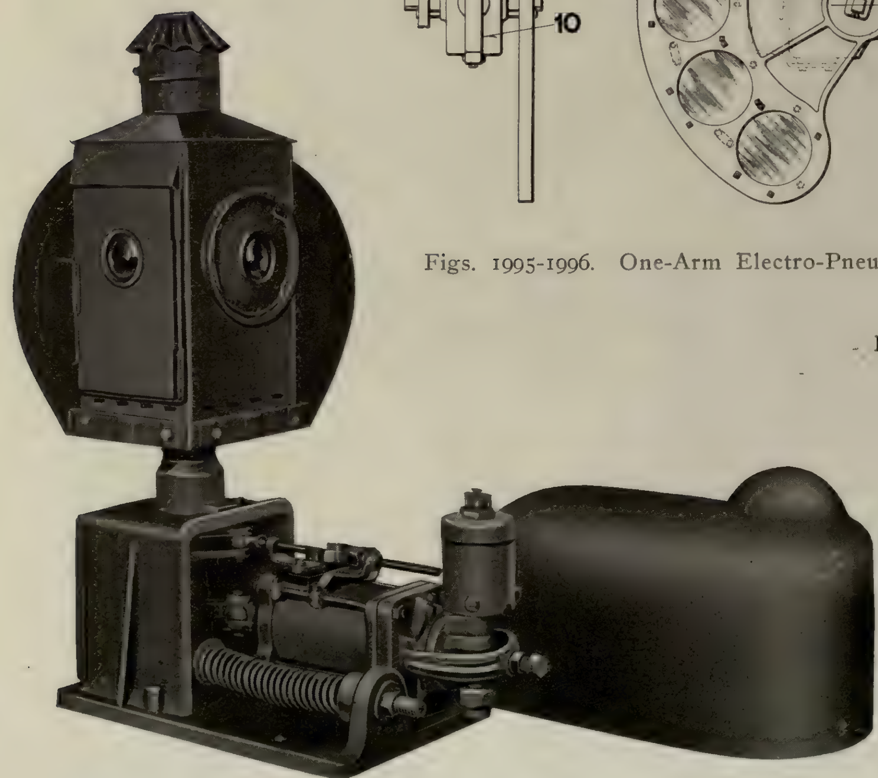


Fig. 1997. Electro-Pneumatic Rotary Pot Signal.

Fig. 2014 shows the arrangement of circuits and apparatus for controlling the drawbridge over the Charles River, where it is crossed by the Boston Elevated Railroad. Attached to the structure is a circuit controller F, which closes the circuit

*Note.—For electric detection applied to electro-pneumatic interlocking see Figs. 2001-2002, 2009-2013.

energizing the draw indicator only when the draw is in proper position, both with respect to its vertical and horizontal alinement. In series with this is another contact G, which insures the proper position of the wedges supporting the draw ends before the circuit is closed. When this circuit is complete the draw indicator clears, permitting the operation of the draw lock by reversing lever 21, and also permitting signals 18-L

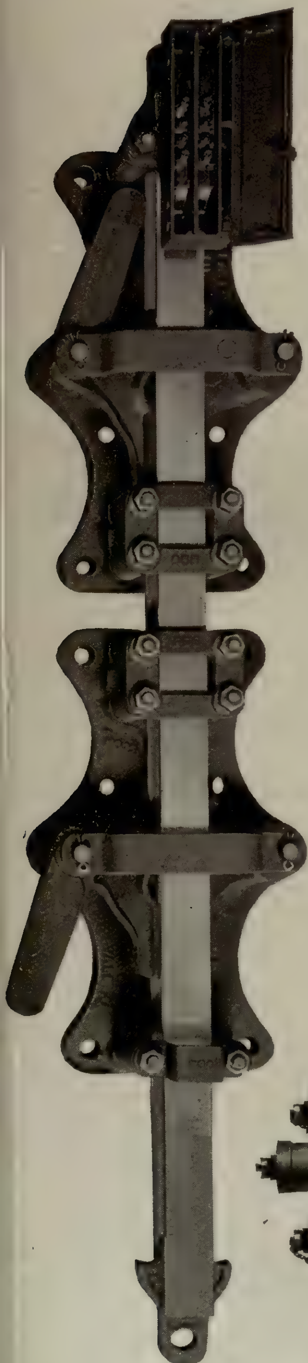


Fig. 1998. Electro-Pneumatic Tandem Switch and Lock Movement for Use with Movable Frogs.

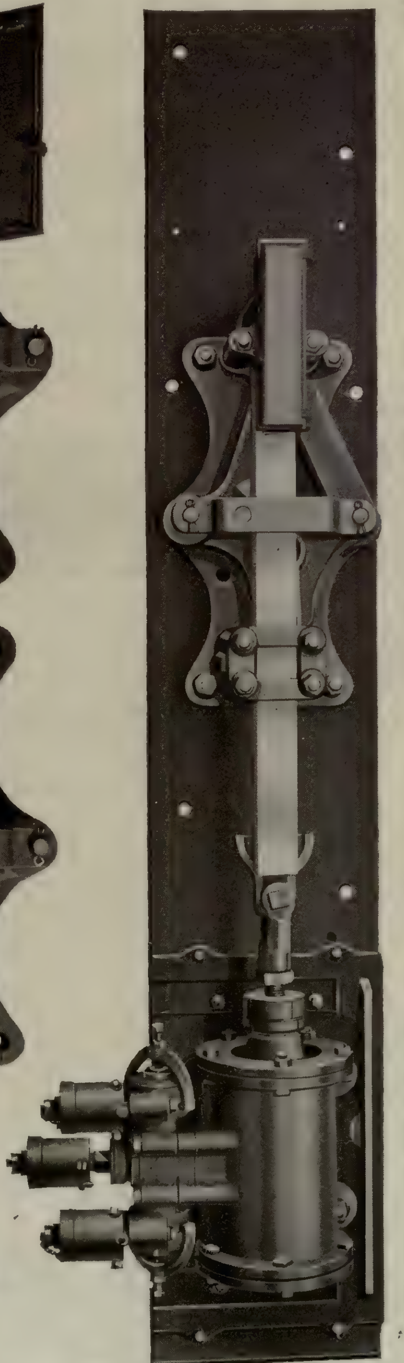


Fig. 1999. Electro-Pneumatic Switch and Lock Movement Attached to Bed-Plate. For Use with Single Switch.

and 20-R to be cleared for traffic. These signals are also interlocked with lever 21. When it is desired to open the draw (signals 18-L and 20-R being set in the stop position), lever 21 is moved to normal, withdrawing the draw lock, which is operated by the plunger cylinder C. When this lock is withdrawn circuit controller B closes a local circuit which energizes lock L on the draw tender's gearing, releasing same and permitting him to open the draw.

Fig. 2000 shows the circuits for the control of the electro-pneumatic switch valves from their levers, and the control of the levers by the indicating contacts of the switch movements, as originally used. This arrangement of control circuits has been quite extensively used for electro-pneumatic installations during the past 20 years and until quite recently.

The advent of electric track circuit locking of switch levers as a substitute for detector bars is a feature in the circuits shown in Fig. 2001. These retain the original control of the switch valve by the lever, but draw the energy for indicating

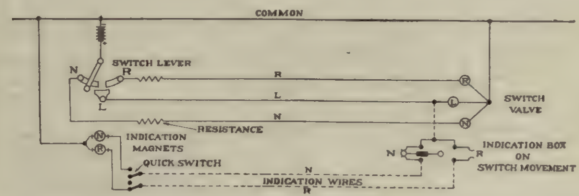


Fig. 2000. Single Switch Control and Indication Circuits as Used Without Automatic Locking.

purposes from a battery feed wire running throughout the plant for general purposes that call for energy taken from points distant to the tower. The current supplied to the indication locks of the switch movement is thus of a continuous nature, and not present simply during the operation of the switch, as heretofore when this current supply was drawn from the wiring energizing the lock magnet of the switch valve. The same battery wire supplies current through the track relay for the direct operation of an electric lock engaging the switch lever, in the manner which is customary in general practice on other machines.

Fig. 2002 shows the modifications of Fig. 2001, in which the separate electric lock is dispensed with and the two indication

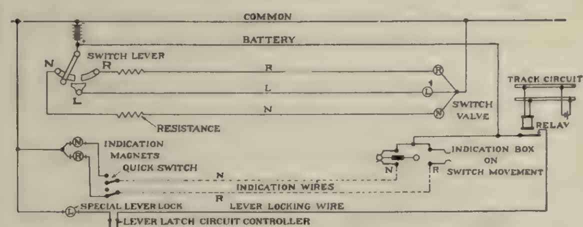


Fig. 2001. Single Switch Control and Indicating Circuits with Special Circuit and Magnet for Automatic Switch Locking.

magnets are employed to perform alternately the function of automatically locking the switch by a train on the track circuit. To accomplish this, certain additional springs were applied to the switch lever for transposing the indication magnets from the duty of indicating the switch's position, to the duty of locking the lever automatically, as is apparent from the diagram. This is the method that has been generally followed during the past five years in electro-pneumatic plants having electric track circuit switch locking.

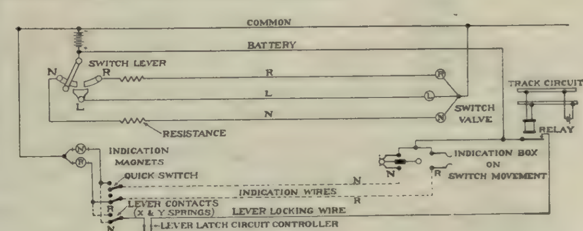


Fig. 2002. Single Switch Control and Indicating Circuits Adapted to Automatic Switch Lever Locking by Indication Magnets.

Fig. 2003 shows a still further modification of Figs. 2000 and 2001 to embrace the feature first referred to as avoiding the introduction of special contacts and the running of an excessive number of wires into switch movements for the control of signals by the position of switch points. This diagram embraces a closed circuit indication wire in one position of the lever or the other, which, acting on a single relay or indicator, maintains that instrument in an energized state only as long as the switch lever and the switch coincide in position. In the event of either one moving out of coincidence, the indicator is

de-energized. Through suitably arranged contact springs on the machine levers, these indicators are made to control the current supplied to each and every signal leading over the particular switch to which the indicator refers, so that irrespective of the complication and size of an interlocking plant, the control of signals of secondary importance by position of the switches is as effectually obtained as in the control of the signals of prime importance and with almost no additional cost or complications in the equipment, such costs and complications as are embraced being confined exclusively to the equipment of the tower itself.

Fig. 2010 shows the arrangement adapted to crossover operation. Fig. 2011, likewise, represents the adaptation to a crossover, while Figs. 2012 and 2013 represent the operation of a crossover by the methods of Figs. 2001 and 2002.

It will be noted that the shifting magnets of crossovers are arranged in series, whereas the lock magnets are arranged in parallel. The reason for this is that the duty to be performed by the locking magnets is considerably in excess of that to be performed by the shifting magnets in switch valves of modern construction.

To obtain a more nearly instantaneous withdrawal and appli-

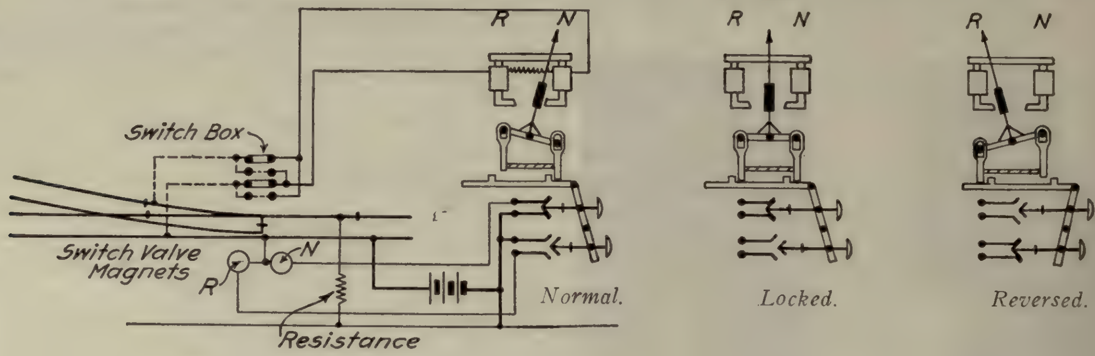


Fig. 2003-2005. Diagram of Typical Circuits for Operating Switches from Electro-Pneumatic Push-Button Machine.

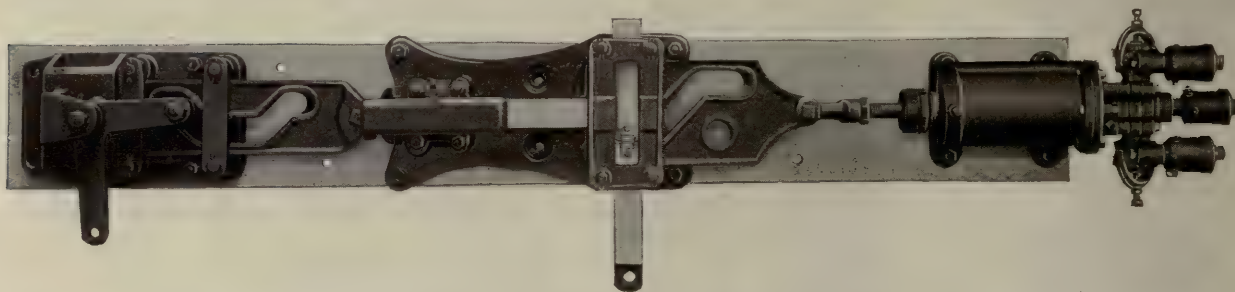


Fig. 2006. Electro-Pneumatic Motion Plate Switch and Lock Movement.

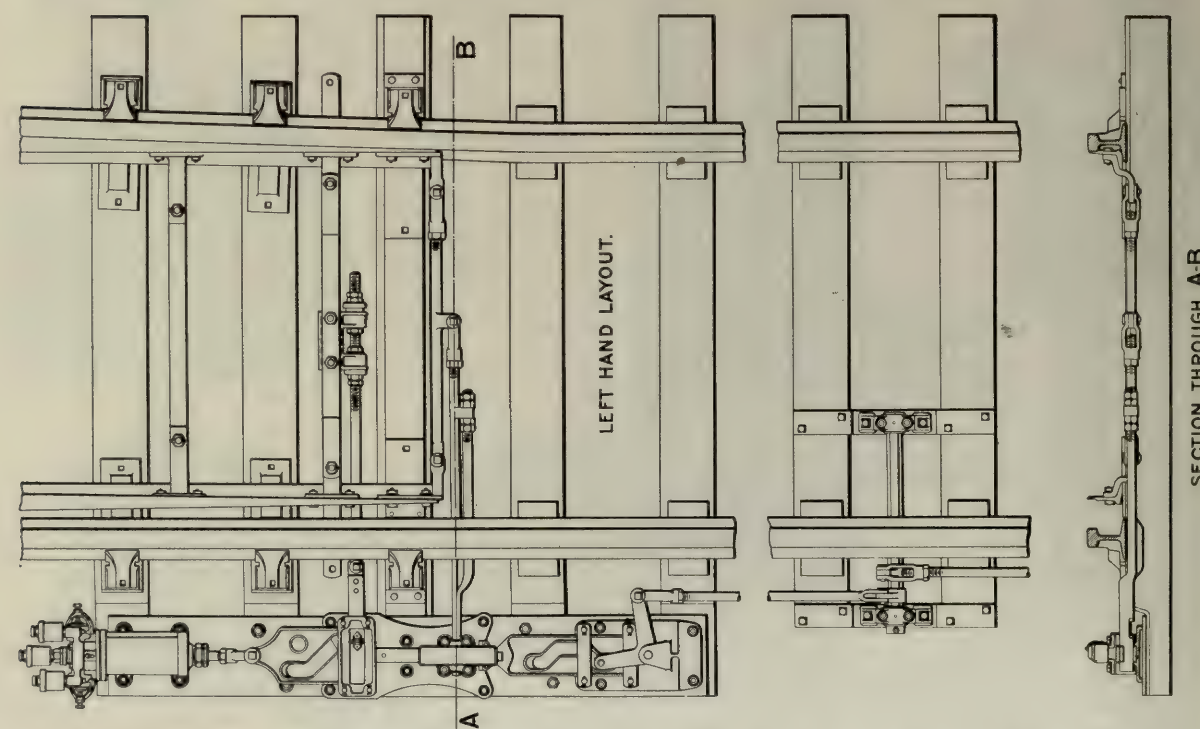


Fig. 2007-2008. Electro-Pneumatic Motion Plate Switch and Lock Movement and Detector Bar Movement, Applied to a Single Switch, With One Detector Bar Ahead of Points; Adjustable Lock Rod.

cation of the D valve lock, pin valves of larger area have recently been introduced, which somewhat increased the work to be performed by the lock magnet. Hence, a greater electrical energy is entailed in this magnet than formerly, and the arrangement in parallel, as shown on the diagrams, permits of operation from the same battery or generator that supplies the shifting magnets of switch valves, without resorting to a difference in the resistances of switch valve magnets in general.

The extra consumption of energy thus caused by the lock magnets is insignificant, for the reason that these magnets are never upon closed circuit excepting during the operation of the switch.

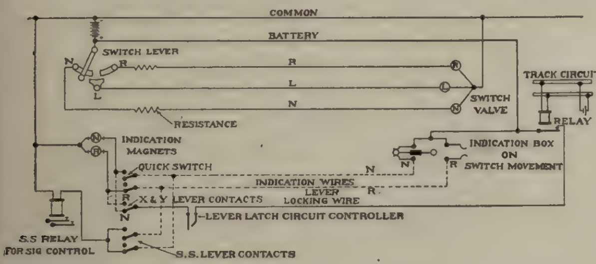


Fig. 2009. Single Switch Control and Indicating Circuits Using Indication Magnets for Automatic Switch Locking and Indication Circuits for Control of Signal by Position of Switch.

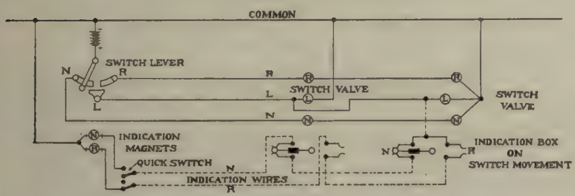


Fig. 2010. Crossover Control and Indicating Circuits as Used Without Automatic Locking.

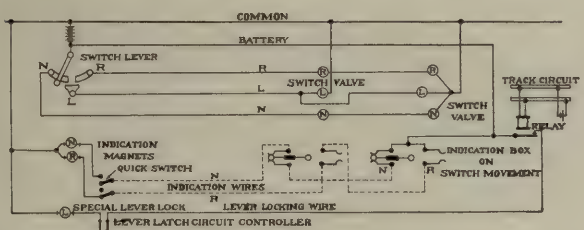


Fig. 2011. Crossover Control and Indicating Circuits With Special Circuit and Magnet for Automatic Switch Locking.

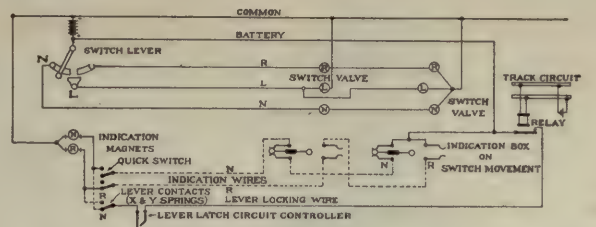


Fig. 2012. Crossover Control and Indicating Circuits Adapted to Automatic Switch Lever Locking by Indication Magnets.

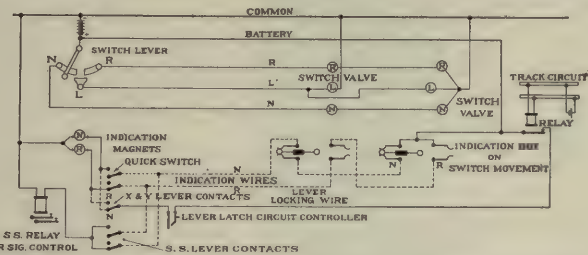
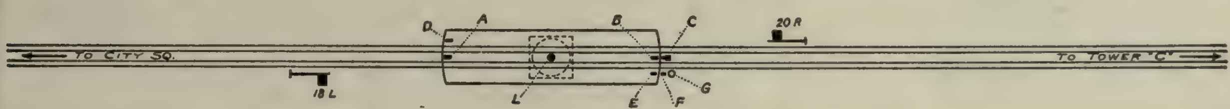


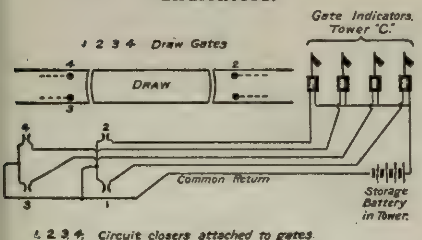
Fig. 2013. Crossover Control and Indicating Circuits Using Indication Magnets for Automatic Switch Locking and Indication Circuits for Control of Signal by Position of Switch.

Names of Parts of Fig. 2014.

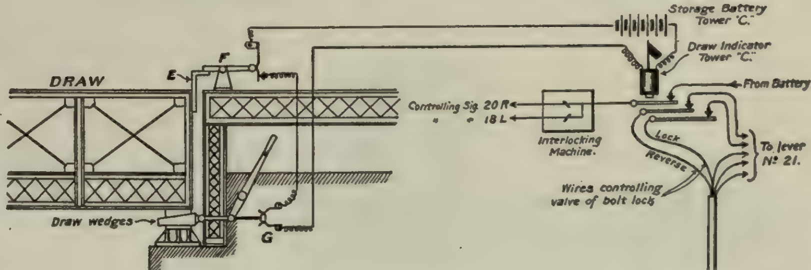
A B	*Circuit Closer and Bridge Bolt Keeper*
C	*Electro-Pneumatic Bridge Lock Plunger*
D E	*Brackets, Operating F*
F	*Bridge Alinement Circuit Closer*
G	*Circuit Closer on Wedges of Bridge*
L	*Electric Lock on Valve of Draw Mechanism*
18-L, 20-R	*Bridge Signals*

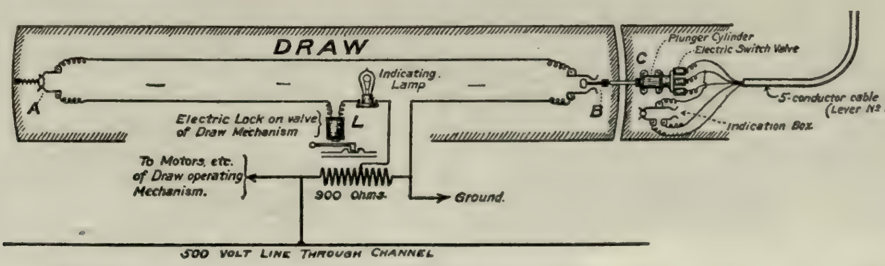


Circuits Controlling Gate Indicators.

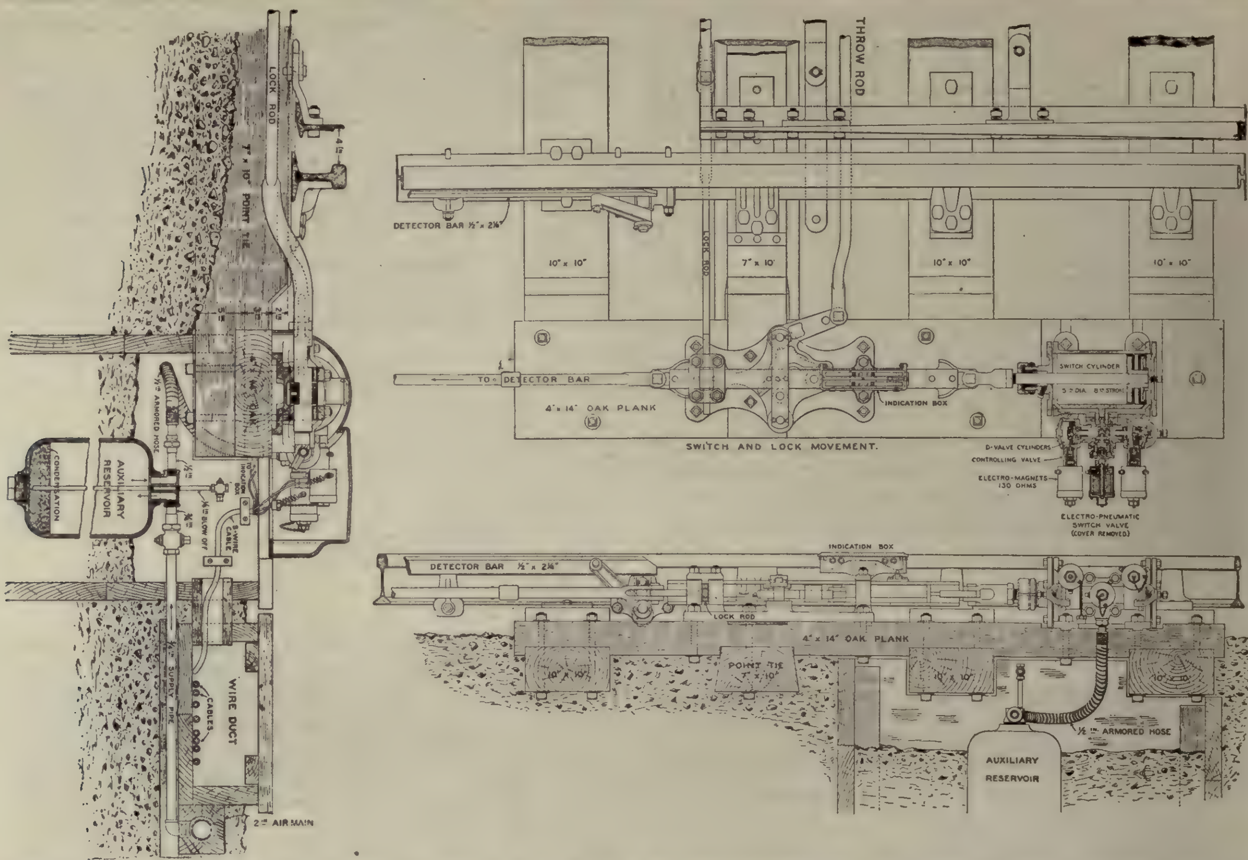


Circuits Controlling Draw Lock and Signals.





Figs. 2014-2016. Circuits for Drawbridge Protection. Boston Elevated Railroad.

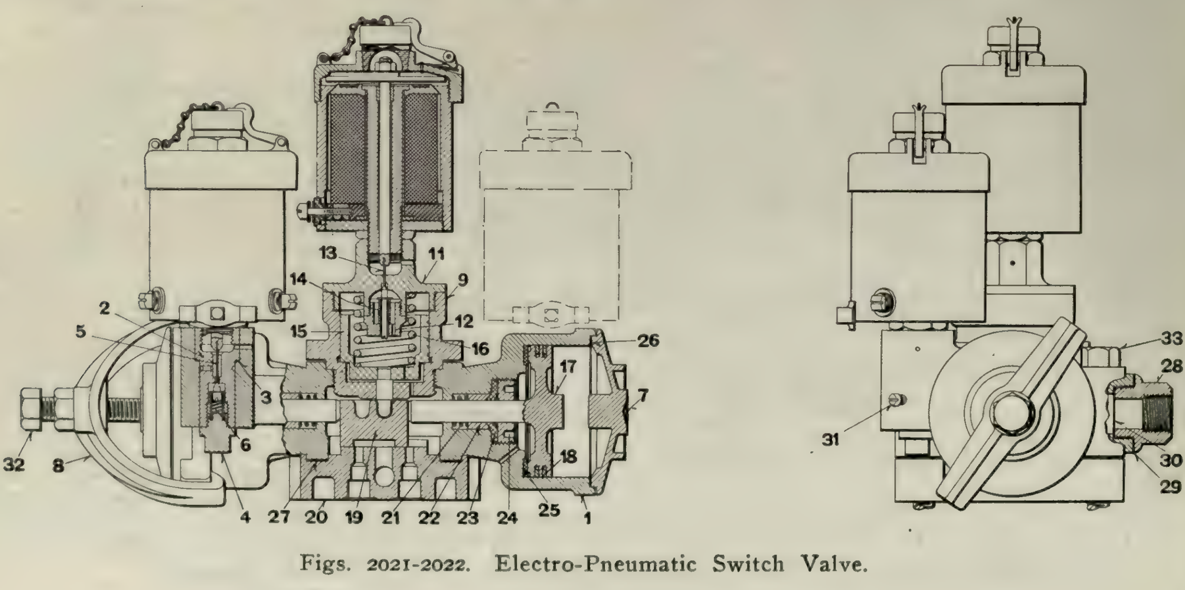


Figs. 2017-2019. Electro-Pneumatic Switch and Lock Movement Applied to Single Switch With One Detector Bar Ahead of Points; Cylinder and Movement Set on Plank. (Later Construction Provides for an Iron Bed Plate, as in Figs. 1999 and 2006.)

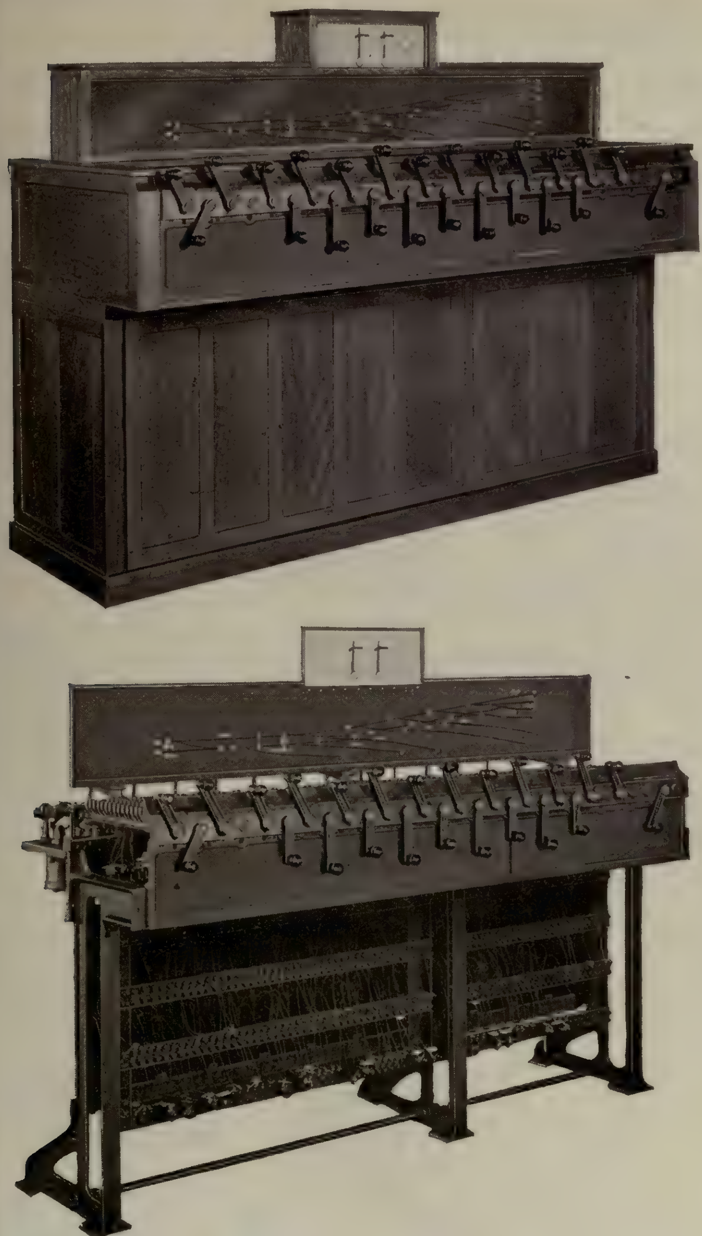
Fig. 2020. Lock Rod, for Figs. 2017-2019.

Names of Parts of Electro-Pneumatic Switch Valve; Figs. 2021-2022.

1 *Valve Chamber*
2 *Guide for Pin Valve*
4 *Pin Valve Plug*
5 *Pin Valve*
6 *Pin Valve Spring*
7 *Head for Valve Chamber*
8 *Yoke*
9 *Lock Cylinder*
11 *Head for Lock Cylinder*
12 *Pin Valve Guide for Lock Cylinder*
13 *Pin Valve for Lock Cylinder*
14 *Pin Valve Spring for Lock Cylinder*
15 *Piston for Lock Cylinder*
16 *Spring for Lock Cylinder*
17 *Piston for Switch Valve*
18 *Piston Rings for* 17
19 *D-Valve*
20 *Valve Seat*
21 *Spring for Stuffing Box*
22 *Gland for Stuffing Box*
23 *Packing for Stuffing Box*
24 *Nut for Stuffing Box*
25 *Gasket for Piston Seat in Valve Chamber*
26 *Gasket for Head of Valve Chamber*
27 *Gasket for Valve Seat*
28 *Union for Valve Chamber*
29 *Washer for* 28
30 *Strainer for* 28
31 *Oil Plug*
32 *Tap Bolt for Yoke*
33 *Tap Bolt for Fastening Valve Chamber and Seat to Cylinder*



Figs. 2021-2022. Electro-Pneumatic Switch Valve.



Figs. 2023-2024. Electro-Pneumatic Interlocking Machine; Vertical Roller Type.

Fig. 2025. Electro-Pneumatic Dwarf Slide Signal. Interborough Rapid Transit Company.

Fig. 2026. One Section of Mechanism, Fig. 2028, Electro-Pneumatic Push-Button Machine.

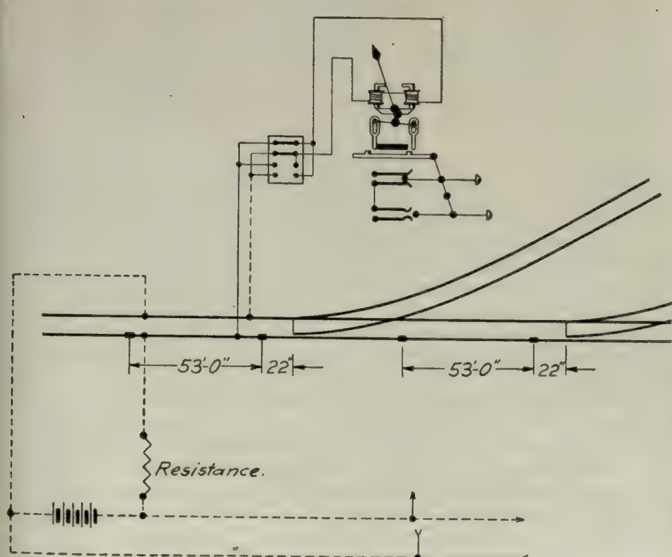


Fig. 2027. Arrangement of Insulated Joints at Switches Controlled by Push-Button Machine.

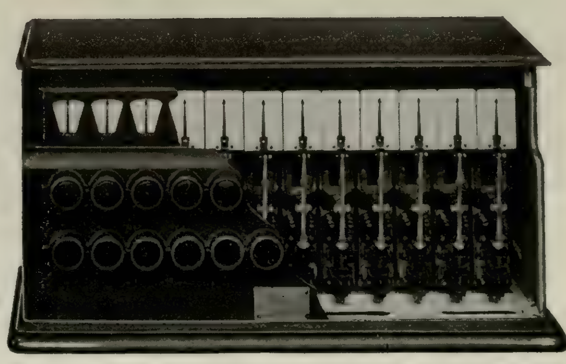


Fig. 2028. Electro-Pneumatic Push Button Machine. Union Switch & Signal Company.

LOW-PRESSURE PNEUMATIC INTERLOCKING

Interlocking apparatus worked by compressed air at low pressure (15 lbs. per sq. in.) and with no electrical features is made by the General Railway Signal Co., and is in use on a number of railways. Compressed air in separate pipes is employed to control the admission of pressure to the switch and signal cylinders. Pressure is admitted to working cylinders by valves actuated by large rubber diaphragms, which are worked by air at seven lbs. pressure. The lever of a switch cannot complete its stroke until the switch has actually moved home and conveyed an indication of the fact to the cabin. The interlocking is mechanical, the parts being made small. They are of the "Standard" type (Figs. 855-901). While the action of compressed air in pipes is not instantaneous, like an electric impulse, the movement of switches is effected quickly enough for all practical purposes; and at ordinary distances the movement of a signal is practically simultaneous with its lever.

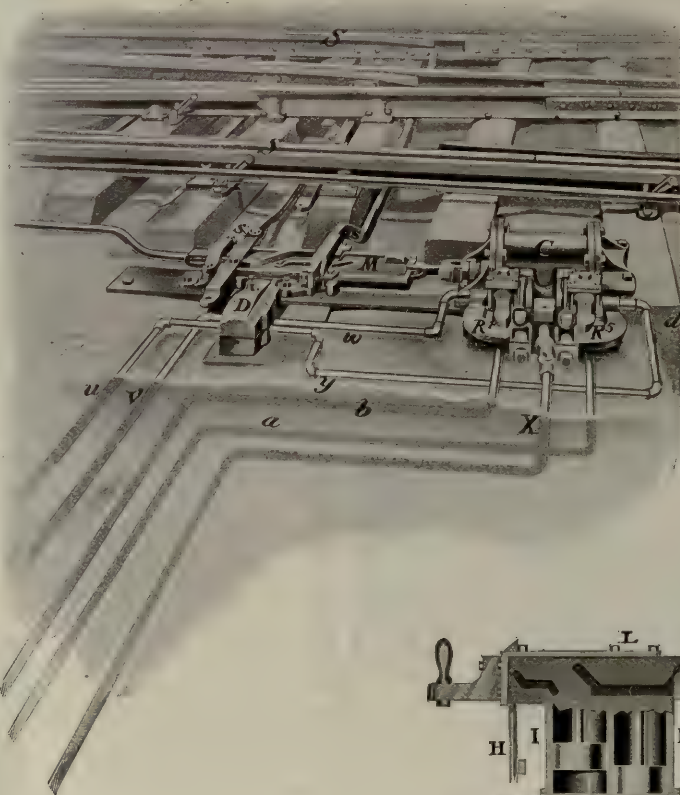
The distinctive features of the low-pressure pneumatic interlocking machine are: (1) A row of slide valves (called levers) like that shown in outline at L and L^2, Figs. 2029 and 2031. (2) The mechanical interlocking frame, placed vertically on the front of the machine. The manner of connecting the lever with the interlocking is indicated by the position and arrangement of the tappet H in Fig. 2029. (3) The indicating cylinders and their relays on each lever, as shown in Figs. 2029 and 2031.

Application of air pressure is required in every case to accomplish any movement. To move a switch or signal from normal to reverse position and to receive a return indication at the machine, an air pressure must be applied at the lever. All signals are held in the proceed position by air pressure under the piston, the entire reverse operating line being charged from the tower to the signal when the signal lever is reversed. Thus absence or failure of power will always leave the signal in the stop position.

The appearance of the machine is shown in Fig. 2040, and the way in which the pressure is conveyed and controlled is shown in Figs. 2029 and 2031. Fig. 2029 represents the arrangement of valves and pipes forming the connection between the interlocking machine and a switch cylinder. The principal parts are: S, switch rails; s, lock-rod; s^1, throw rod; M, motion plate; C, switch cylinder; D, indicating valve; R^2, R^3, R^4, R^5, controlling valves or relays; L, L^2, operating bar and slide valve on lever; I, I^2, indication cylinders; H, interlocking tappet; X, air reservoir.

Names of Parts of Low Pressure Pneumatic Control Mechanism; Fig. 2029.

- C *Switch Cylinder*
- D *Indicating Valve*
- H *Tappet*
- I *Normal Indication Cylinder*
- I^2 *Reverse Indication Cylinder*
- L *Lever*
- L^2 *Slide Valve*
- M *Motion Plane*
- R^2 *Normal Indication Diaphragm Valve or "Relay."*
- R^3 *Reverse Indication Diaphragm Valve or "Relay."*
- R^4 *Normal Operating Diaphragm Valve or "Relay."*
- R^5 *Reverse Operating Diaphragm Valve or "Relay."*
- S *Switch Rails.*
- X *Air Reservoir*
- a *Reverse Control Pipe*
- b *Normal Control Pipe*
- d *Long Tie Supporting* C
- s *Lock Rod*
- s^1 *Throw Rod*
- u *Normal Indication Pipe*
- v *Reverse Indication Pipe*
- w *Normal Indication Pipe Between Cylinder and Indicating Valve*
- y *Reverse Indication*



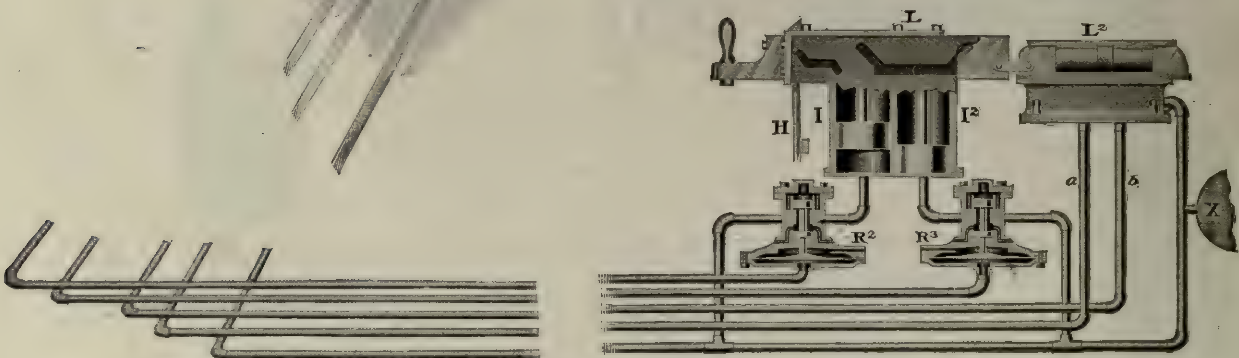


Fig. 2029. Low-Pressure Pneumatic Switch Movement and Lever Connections.

To reverse the position of the switch the signalman pulls the lever L to the left. In doing this he admits air (from the main supply X through the valve L^2) through pipe *a* to valve R^5, which opens communication from the supply pipe X to the right-hand end of the cylinder C, pushing the piston to the left. Observing now the slots in L and M, it will be noted that after about one-half of the stroke L has been completed it is stopped by the piston rod of I^2; but the operation of valve R^5, already accomplished, causes M to move through the whole of its stroke. This stroke of M is uninterrupted, but it performs in succession three functions. The first part of the stroke, say one-third, does not move the switch, but valve D is moved far enough to close the two pipes on its right, while those on its left are open to the atmosphere. At the same time lock bar *s* has been liberated by withdrawal of a dog attached to M from notch in *s*. As M moves through the next or middle portion of its stroke, it moves the switch; but it now produces no effect on valve D, because the rod of D is now engaged by they straight portion of its slot in plate M. The switch being set, the third and final part of the stroke

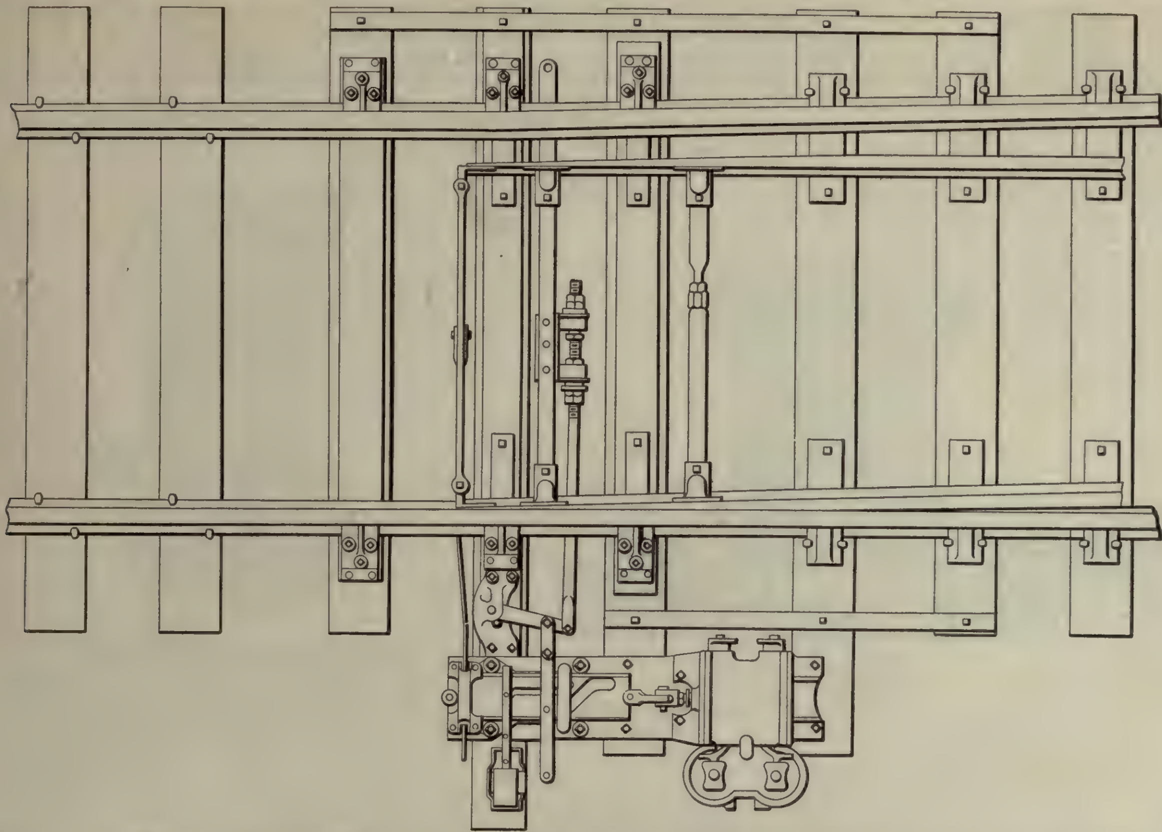
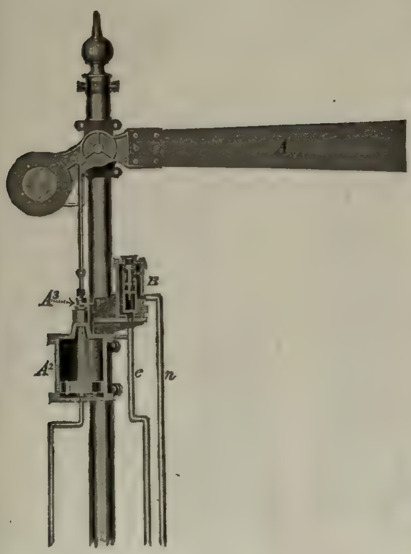


Fig. 2030. Low-Pressure Pneumatic Switch and Lock Movement With Gain-Stroke Lever. New York Central & Hudson River.



Names of Parts of Low Pressure Pneumatic High Signal and Control Mechanism; Fig. 2031.

A	*Signal Arm*	R^1	*Reverse Indication Diaphragm Valve or "Relay"*
A^2	*Signal Cylinder*	R^2	*Normal Operating Diaphragm Valve or "Relay"*
A^3	*Indicating Valve Lever*	R^3	*Reverse Operating Diaphragm Valve or "Relay"*
B	*Indicating Valve*	X	*Air Reservoir*
H	*Tappet*	a	*Reverse Control Pipe*
I	*Indication Cylinder*	b	*Normal Control Pipe*
L	*Lever*	e	*Normal Control Pipe on Signal*
L^2	*Slide Valve*	n	*Indication Pipe*

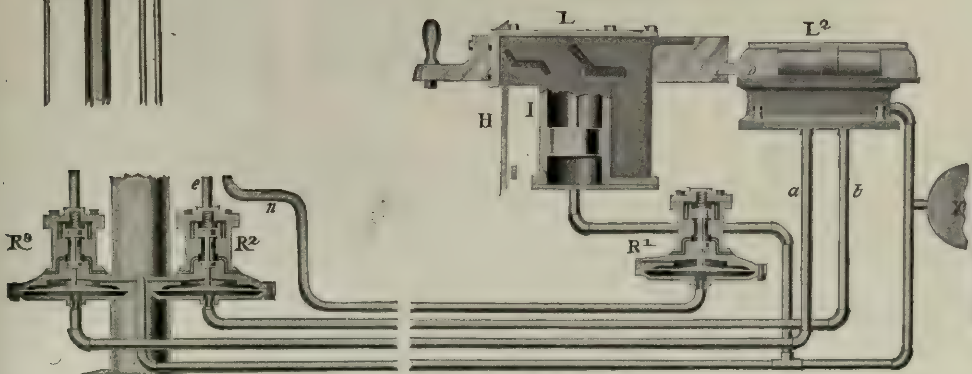


Fig. 2031. Low-Pressure Signal Movement

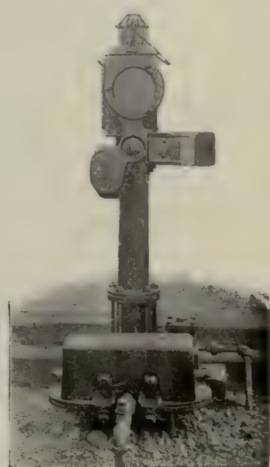


Fig. 2032. Low-Pressure Pneumatic Dwarf Signal.

of M locks the switch by pushing a second dog attached to M through a second notch in *s*; and also (but not until after the dog has entered its notch) the plate changes valve D so as to connect together the two pipes *y* and *v*. This conveys pressure from the supply through R^5 and D to valve R^6, which valve then admits air from the supply to I^2, forcing the piston rod upward, and, by means of the diagonal portion of the slot in lever L, forcing it to complete its stroke. This return action takes place at ordinary distances in from one to three seconds. In rapid work, this automatic completion

of the stroke of the lever saves an appreciable portion of the signalman's time. By the action of L^2 pipe *a* is now opened to the atmosphere, valve R^5 is released from pressure, and R^4 is closed; so that the right-hand pipe to cylinder C and its connection to and through D are open to the atmosphere. All four operating pipes are now at atmospheric pressure.

By the movement of L, tappet H has been moved so as to produce, in the first part of the stroke of L, the proper mechanical locking of conflicting levers, and in the last part of this stroke, the proper unlocking in the same manner and

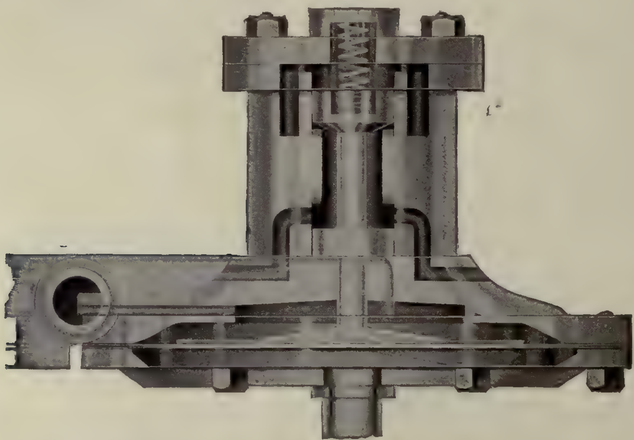
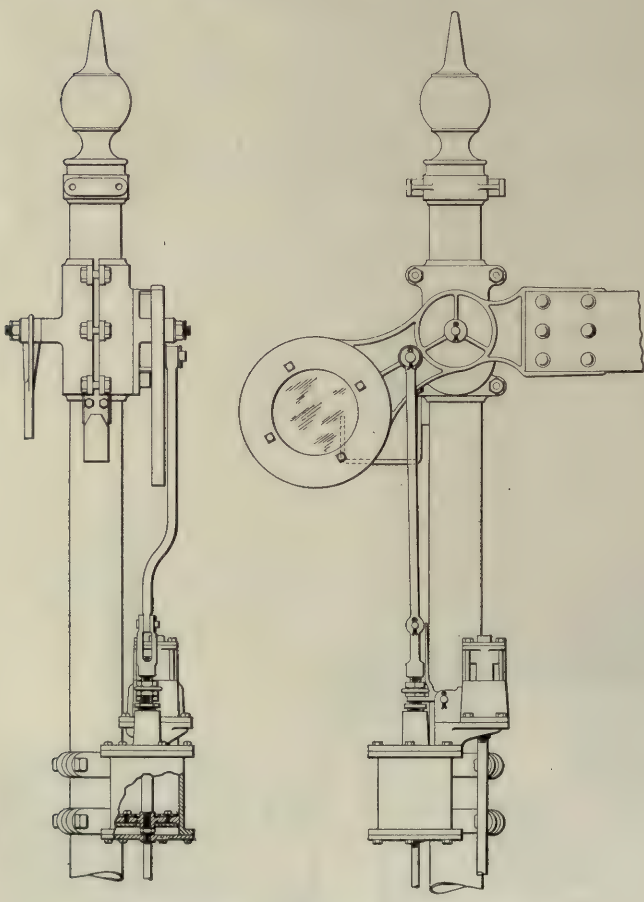


Fig. 2033. Pneumatic Diaphragm Valve or "Relay."



Figs. 2035-2036. Pneumatic High Signal.

sequence that the same interlocking would have effected in a mechanical interlocking machine.

To move the switch back to its original position, the opposite set of pipes is used. The lever L is pushed to the right; air through *b* actuates R^4, and the return indication to the cabin actuates R^2 and lifts the piston in I.

A crossover switch or slip with movable point frogs is operated in the same manner excepting that the functions are connected in series, the air leaving valve D, going to the diaphragm operating the second function in the same manner as described for the operation of the first function. Pipes to any number of movements may be connected in series and operated from one lever in this manner, the indication from a preceding movement operating a following one, the last movement to operate giving the indication at the machine and automatically completing the stroke of the lever.

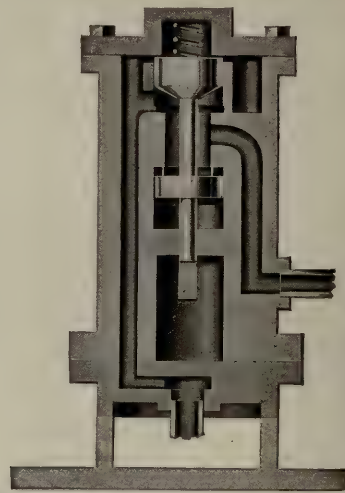


Fig. 2034. Indicating Valve for High Signal (B, Fig. 2031).

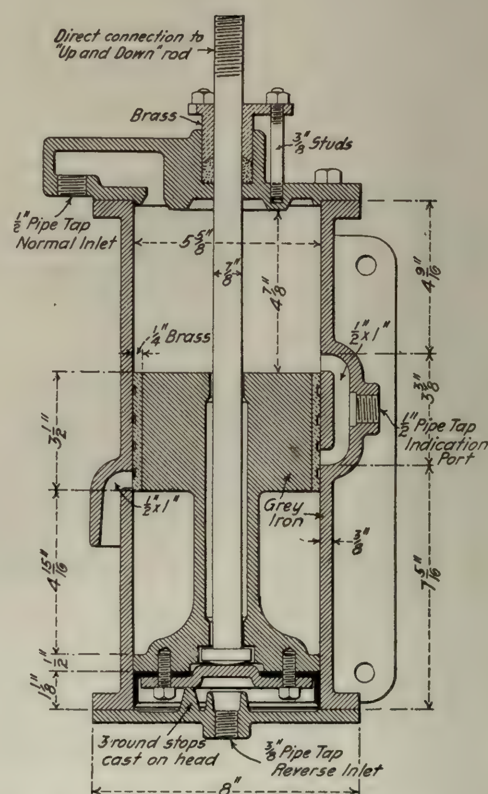


Fig. 2037. Improved Type of Cylinder for Pneumatic High Signal.

To work a signal, valves and operating pipes are used of the same general style as those for a switch, but there is only one indicating valve and one indicating cylinder, as it is considered unnecessary to assure the attendant that a signal is in the proceed position. The signal connections are shown in Fig. 2031. The principal parts are: A, signal arm; A^2, signal cylinder; A^3, lever to work indicating valve; B, indicating valve; R^2 and R^3, diaphragm valves or relays, controlling the admission of air to the top and bottom, respectively, of the signal

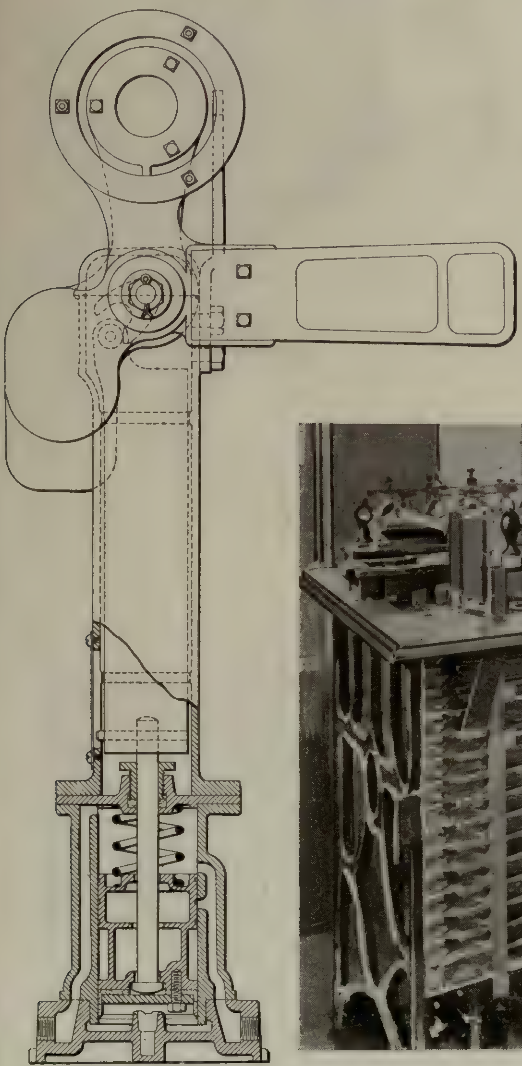
cylinder; R^1, diaphragm valve controlling admission of air to cylinder I. The signal being in the normal or stop position, the indicating valve B is in a position to maintain a connection between the two pipes attached to it; but as soon as the signal arm leaves the horizontal position the valve shuts off this connection.

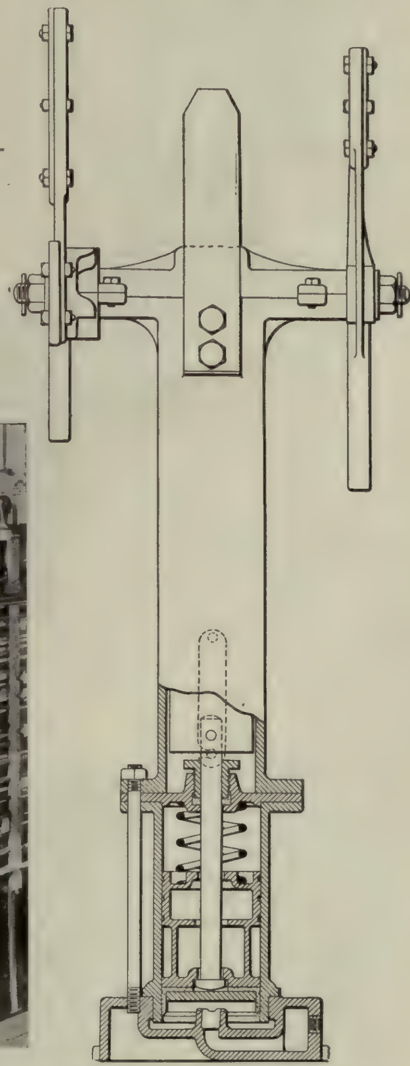
To clear the signal the signalman pulls L to the left the whole length of its stroke. By this movement L^2, admitting air to pipe *a*, actuates valve R^3, which supplies air to the lower end of cylinder A^2 and pushes up the piston, putting the signal in the proceed position. The air impulse is transmitted so quickly that at the average distance (say 500 ft. or less) the movement of the signal is practically simultaneous with the movement of the lever. The signal remains in the proceed position as long as L is pulled to the left. To restore it to the normal or stop position, L is pushed to the right until it is stopped by the piston rod of I (at the end of the horizontal part of the slot in L). With L in this position, pipe *b* is charged and valve R^2 is opened. The passage between pipes *e* and *n* (through B) is now closed, so that the opening of R^2 admits air from the supply to the upper end of A^2. This restores the signal to the horizontal position, and by means of A^2 opens valve B. Air now passes from *e* through B and *n* to R^1, and the latter causes air to enter I and complete the return stroke of L by the action of the piston rod on the diagonal part of the slot. Pipes *b*, *e* and *n* are now at atmospheric pressure; and the parts are in the same position as at the beginning.

In Fig. 2033 is shown the diaphragm valve, which is called the "relay," its function being similar to that of an electromagnetic relay in electrical apparatus. This valve is actuated by air at seven lbs. pressure. This pressure, admitted beneath the circular rubber diaphragm eight in. in diameter, pushes up the cylindrical valve, placed vertically in the upper part of the case, and thereby admits air at 15 lbs. per sq. in. to move the piston in the switch or signal cylinder. The movement of the diaphragm is only one-fourth in.

The operating and indicating pipes extending to switches and signals are one-half in. in diameter. The supply pipes from the air reservoirs are larger, the size being varied according to the number of switches and signals to be operated. The air as it comes from the compressor is run through cooling pipes for the purpose of precipitating moisture.

Any number of signals controlling relative movements over the same switches may be connected up to one signal lever by placing selector valves at switch points to control the admission of air to the proper signal line. This method provides practically the same protection as bolt locking the switch points with signal lines at mechanical plants.





Figs. 2038-2039. Low Pressure Pneumatic Dwarf Signal.

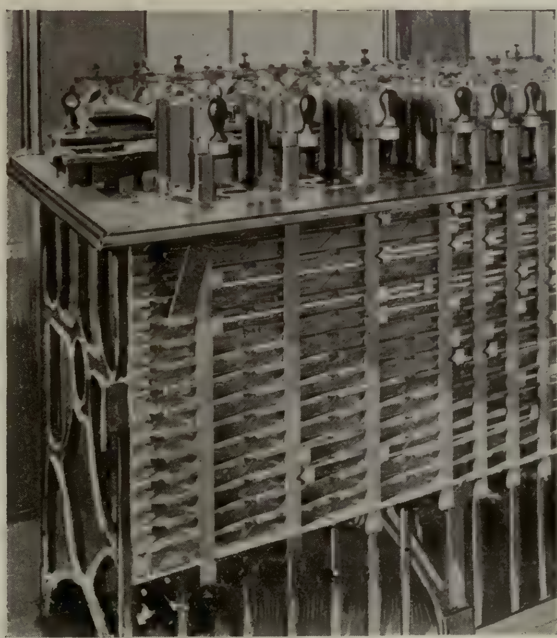


Fig. 2040. Low-Pressure Pneumatic Interlocking Machine.

Fig. 2030 shows the method of providing a gain stroke lever from switch and lock movement to switch point, and also shows the general appearance of a switch connected up to the low pressure system, for either rear or advance bar movements.

The common type of semaphore movement used with the low pressure pneumatic system is shown in Figs. 2035-2036; the movement is effected by the operation of the relays, controlled by the signal lever in the machine as explained in Fig. 2031. An improved semaphore movement, known as style B, is shown in Fig. 2037. The principles of operation are the same as described in connection with Fig. 2031, excepting that the indication is controlled by a piston so arranged as to pass the air from the normal side of the piston to the indication line when the signal arm has assumed the stop position.

Figs. 2038-2039 show a style E pneumatic dwarf signal. The operation is effected through the same control medium as shown in Fig. 2031; the indication, however, is controlled by a piston valve in the same manner as shown in Fig. 2037.

ELECTRO-MECHANICAL INTERLOCKING.

The electro-mechanical machine applies many of the advantages of power interlocking to a mechanical plant; requires less energy for its operation; provides a reliable means for switch and signal indications; permits the use of electric detector locking; eliminates facing point locks, bolt locks and detector bars and in addition reduces the size of the tower required.

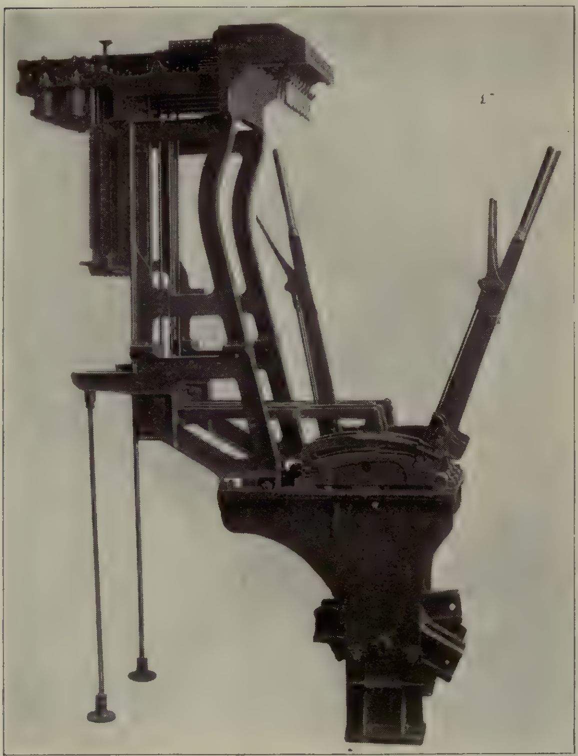


Fig. 2041. Style "P" Electro-Mechanical Interlocking Machine. Union Switch & Signal Company.

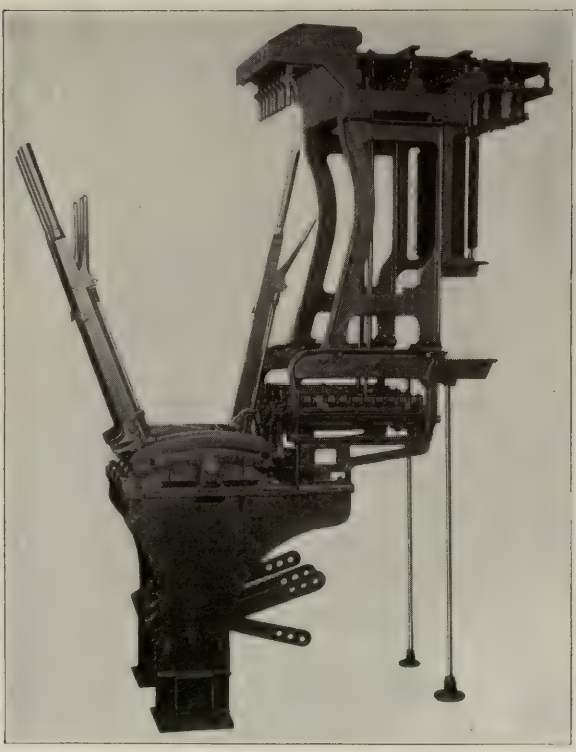


Fig. 2042. Style "S" Electro-Mechanical Interlocking Machine. Union Switch & Signal Company.

Fig. 2043. Electro-Mechanical Interlocking Machine. General Railway Signal Company.

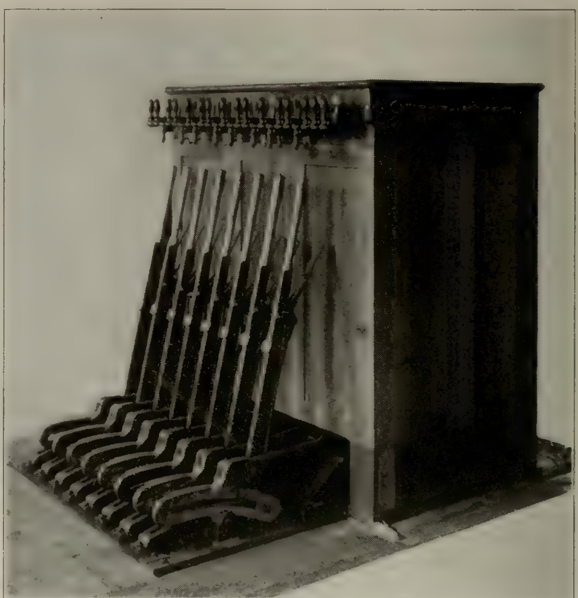


Fig. 2044. Electro-Mechanical Interlocking Machine. General Railway Signal Company.

UNION STYLE "P."

The large machine is of the Saxby & Farmer type and is furnished in standard sections, the levers being spaced five in. center to center. The miniature levers, spaced two and one-half in. centers, are mounted above the large levers and so arranged that the small controlling switch levers are directly over the large levers controlled by them. The miniature signal control levers are placed between the switch levers and are for control of power operated signals.

The mechanical locking between levers is actuated entirely by the miniature levers, thus reducing to a minimum the liability of forcing or straining the locking. The miniature levers

in turn lock the large levers through vertical rods connected to the shaft and horizontal rods operated by the rocker on the large levers, the locking being accomplished by slots in the rods smiliar to the slots in mechanical bolt locks.

The actual operation of a switch is accomplished by the large lever, and the mechanical locking actuated and indication taken from the miniature one. The electric levers are fitted with the electric lock and spring combination features identical with those used on the electro-pneumatic interlocking machine as explained in the description of that machine.

The miniature levers are made in multiples of two. The operation of a switch lever is as follows:

First: Throw the miniature lever to the middle position, actuating the locking and releasing the large lever for the operation of the switch.

Second: Operate the large lever.

Third: Complete the stroke of the miniature lever after the indication is received, which locks the large lever and also completes the stroke of the mechanical locking, releasing the signal levers, etc.

UNION STYLE "S."

The electric levers in the style "S" machine are made up in multiples of four. Any number, therefore, not exceeding the capacity of a given mechanical machine frame may be placed above such a machine as desired.

The electric levers, while principally intended for the control of signals, can also be used for other purposes, such as electric locking between adjoining towers, between towers and outlying switches, direction control of traffic, etc.

The electric levers for the control of signals are placed five in. centers to correspond with the spacing of shafts in the locking bed; levers which do not have connection with the mechanical locking may be placed intermediate of these levers without increasing the length of the frame.

The electric levers are fitted with the electric lock and spring combination features identical with those used on the electro-pneumatic interlocking machine.

From cranks on the shafts of the electric levers, vertical rods connect to rack and pinion drivers for operating the locking bars in the bed of the mechanical machine, these drivers being free to turn on the locking shafts of mechanical levers. By this means any desired locking can be secured between the mechanical and the electric levers.

The electric levers with their supports and connections can be applied to existing mechanical machines by revising the locking to suit conditions and inserting the required number of special locking drivers in the locking bed.

POWER OPERATED SIGNALS AT MECHANICAL PLANTS

Where power-operated semi-automatic signals are used at mechanical interlocking plants, provision is usually made to compel the signalman to put his signal lever normal after the passage of a train. Such signals, if of the automatic type, will clear as soon as the train leaves the block if the lever remains reversed, and permit another train to follow, which might result in delays. For this purpose, some form of "stick" relay wiring may be employed. Fig. 2051 shows circuits for this purpose. The circuit controllers shown are operated by the lever latch. The 500-ohm stick relay is kept energized under normal conditions by a circuit as follows: From the battery D, through wires 4, 6, circuit controller A, wires 9 and 12, coils of relay, wires 10 and 8, circuit controller C and wire 3 to battery. Current can also flow through wire 5, relay point, wires 11 and 12 and to battery through coils. Raising the latch opens circuit controller A. Lowering latch with lever reversed closes circuit controller B and opens C; C does not open, however, before B closes. Current now flows from battery through wires 4 and 5, relay point, wires 11 and 12, coils of relay, wires 10 and 7, circuit controller B, wire 2, track relay point, wire 13, signal mechanism, wire 1, to battery. This clears the signal. Passage of a train opens the track relay points, putting the signal to the stop position and opening the circuit of the 500-ohm stick relay. As the signal control circuit passes through the point of this relay, the signal cannot again clear, because this relay will not be energized again until the lever is latched in the normal position. If the resistance of the coil through which this current passes at the signal is less than 500 ohms, the stick relay winding should be reduced accordingly.

Another circuit arrangement for accomplishing the same results is shown in Fig. 2052. The stick relay has two windings, one of which, D, is energized by the battery A through controller contacts F and E and wires 1, 2, 3 and 0. The circuit controller is of the snap type. Contact G must close just before the other two open when the lever latch is lowered with lever reversed; and E and F must close only when latch is lowered with lever normal. With lever reversed and latched, current flows from battery A, through wire 1, controller contact G, wire 4, coil C of stick relay, wire 5, contact on stick relay, wire 6, contact on track relay, wire 7, signal mechanism, and wire 0 back to battery. This keeps the stick relay energized and clears the signal. The presence of a train in the block opens the track relay and breaks the circuit for the signal and stick relay. This puts the signal to stop and opens the stick relay, which cannot again pick up until the lever is latched normal.

Fig. 2047 is a diagram of circuits in use on the Erie Railroad for electrically operated distant and advance signals, with electric switch locks for outlying switches at an interlocking plant. Circuits east and westbound are similar and have similar numbers. The circuit for distant signal 1 is as follows: From the battery at the tower, through back contact on indicator I, circuit controller P (on lever 1), wire 1, circuit controller V (on signal 3), relay D at signal 1, to common wire 6, back to battery. Indicator I is operated by circuit from battery H at signal 2, through circuit controller G′, wire 4′ and hand switch L. Therefore, to clear signal 1, advance signal 2 must be cleared (closing the contact on I) and also the home signal 3.

Advance signal 2 is controlled by a circuit from the main battery through circuit controller S (on lever 2), wire 5′, relay D (at signal 2), circuit controller B′ (on electric switch lock A′), to common wire 6′. If the lock A′ has been released to open the switch, B′ will prevent signal 2 from clearing.

The switch lock A′ is controlled by the hand switch L, using the same circuit from battery H at signal 2 that operates indicator I. When L is reversed this current passes through wire 3′, switch lock A′, wire 5′ back to battery. When L is reversed indicator I is energized by the tower battery, thereby keeping the circuit for distant signal 1 open. Locks N and

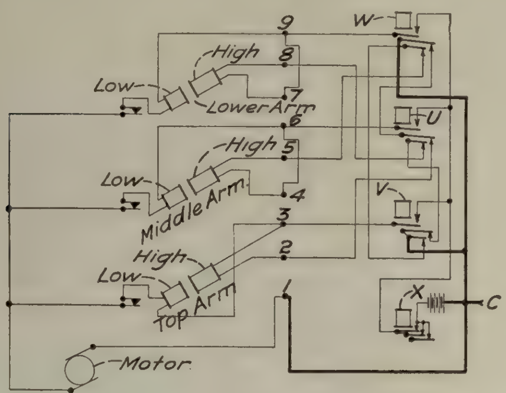


Fig. 2045. Diagram of Control Circuits for Three-Arm Style "B" Union Semaphore Distant Signal at Mechanical Interlocking Plant. Pennsylvania Railroad.

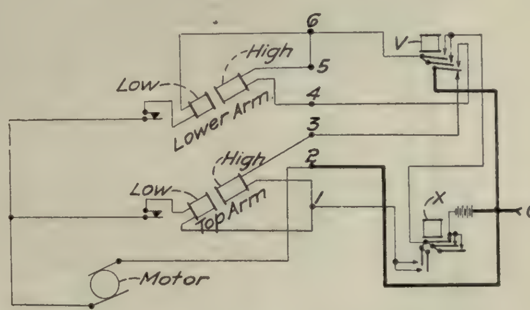


Fig. 2046. Diagram of Control Circuits for Two-Arm Semaphore Distant Signal at Mechanical Interlocking Plant. Union Switch & Signal Company's Style "B" Signal.

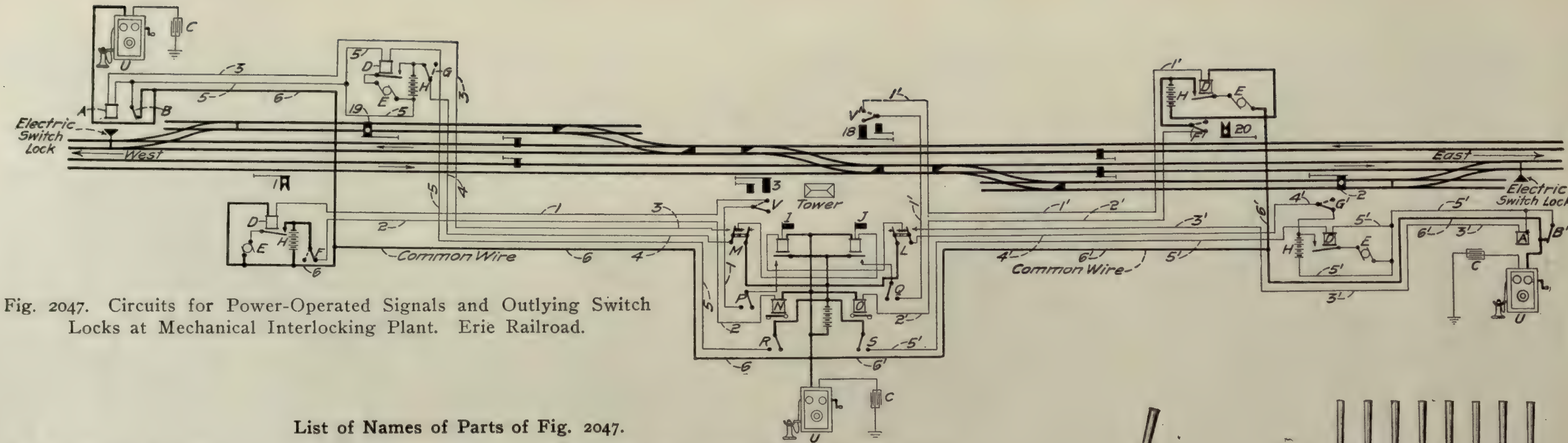


Fig. 2047. Circuits for Power-Operated Signals and Outlying Switch Locks at Mechanical Interlocking Plant. Erie Railroad.

List of Names of Parts of Fig. 2047.

A *Electric Switch Locks*
B *Circuit Controller on Electric Switch Locks*
C *Condensers for Telephone Circuits*
D 500 *Ohm Relays*
E *Signal Motors*
F *Circuit Controller on Distant Signals*
G *Circuit Controller on Advance Signals*
H 16 *Cells, Primary Battery*
I *East Bound Indicator* (1000 *Ohms*)
J *West Bound Indicator* (1000 *Ohms*)
L *Switch for Controlling East Bound Indicator and Electric Switch Locks*
M *Switch for Controlling West Bound Indicator and Electric Switch Locks*
N *Lever Lock on East Bound Home Signal; Locks Latch Up When Lever is Normal* (1000 *Ohms*)
O *Lever Lock on West Bound Home Signal; Locks Latch Up When Lever is Normal* (1000 *Ohms*)
P *Circuit Controller on East Bound Distant Signal Lever*
Q *Circuit Controller on West Bound Distant Signal Lever*
R *Circuit Controller on West Bound Advance Signal Lever*
S *Circuit Controller on East Bound Advance Signal Lever*
U *Magneto Telephone*
V *Circuit Controllers on Home Signals*

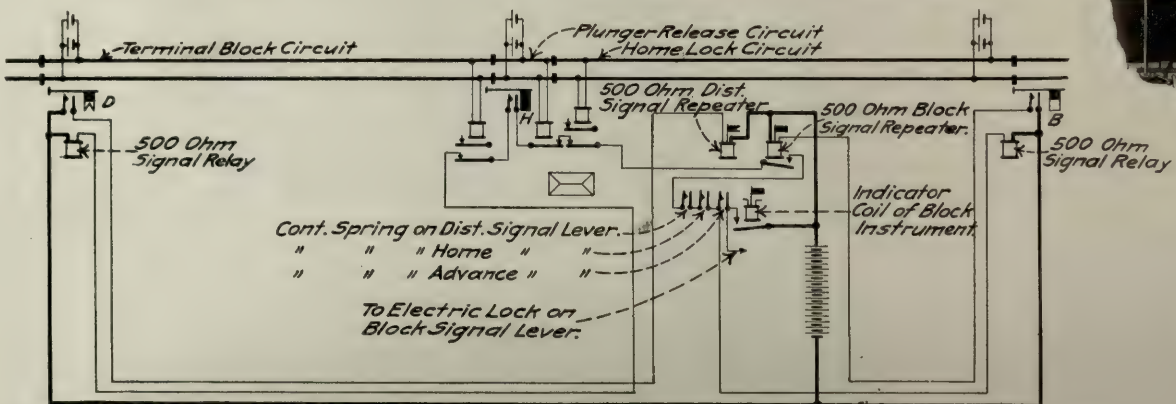
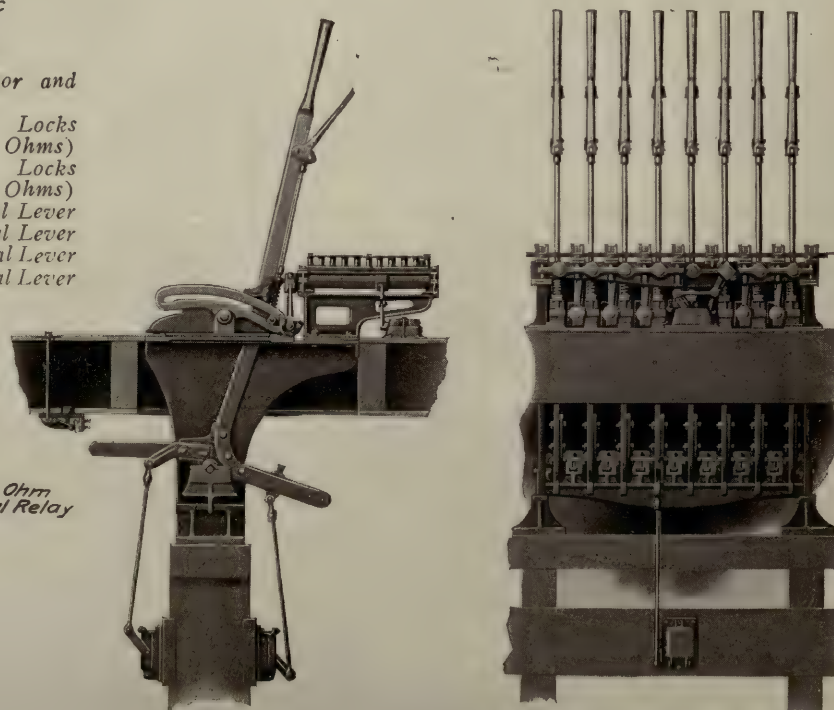


Fig. 2048. Circuits for Power-Operated Distant and Advance Signal at Controlled Manual Block Station. New York Central & Hudson River.



Figs. 2049-2050. Saxby & Farmer Interlocking Machine Showing Various Methods of Applying Horizontal Rotary Circuit Controllers. The Union Switch & Signal Company.

O act on the home signal levers to lock the latches while the distant signal is clear, so that the lever may be put normal, but not latched in that position. The telephones U are installed in the tower and at the outlying switches. Trainmen use these to request an unlock from the signalman. The telephone circuit is carried on the main common on one side, and the ground, through condensers, C, on the other.

G. R. S. MODEL 2A SIGNAL USING DYNAMIC INDICATION.

Figs. 2053-2054 show typical circuits for power operated signals when controlled by the levers of a mechanical interlocking machine. These circuits make use, on low voltage signals, of the dynamic indication which is used in connection with the indicating current effectually checks the speed of the mechanism, thereby eliminating the necessity of having a dashpot to prevent shock to the parts on the arrival of the blade at the normal position.

It will be seen that neither false operation nor indication can result from a cross between the operating and common wires, evidence of existing trouble being given by the blowing of the fuse in the operating circuit. Provisions are made to properly safeguard the circuits when two or more signals are controlled by wires located on the same pole line, this protection being maintained in every case through contacts whose integrity is checked at each operation.

The use of this type of control for power operated signals eliminates the necessity of having isolated batteries with

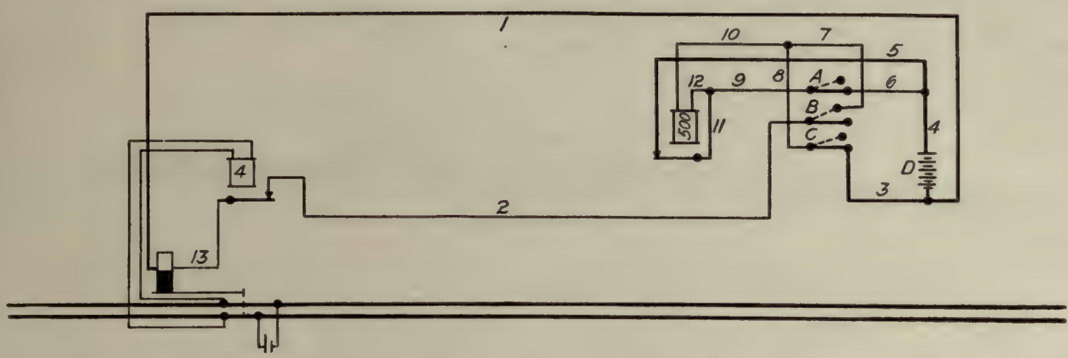


Fig. 2051. Circuit for Power-Operated Signal at Mechanical Interlocking Plant.

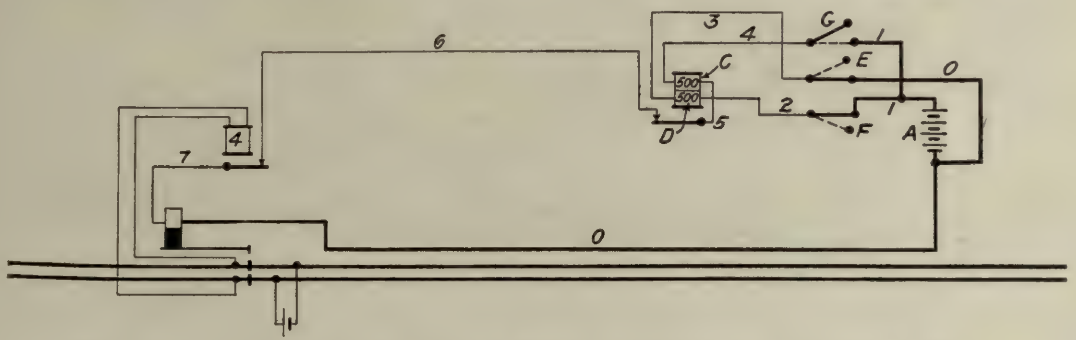


Fig. 2052. Circuit for Power-Operated Signal at a Mechanical Interlocking Plant.

G. R. S. 110-volt all-electric interlocking system. The signals are capable of being controlled semi-automatically by track circuits or non-automatically, and are designed to operate through two or three positions, upper or lower quadrant, right or left hand. The apparatus required has been reduced to a minimum through the use of a central source of energy.

The low voltage Model 2A signals are operated from a battery in the tower, which delivers either 10 or 20 volts at the their expensive housing at each signal location; it also eliminates control relays and relay boxes, cuts out the indication wire necessary to battery indication, and in plants where more than two such signals are installed effects a considerable saving in the number of cells required to operate the functions in question.

When distant signals are controlled by this circuit, special locking is employed which permits the home signal to be

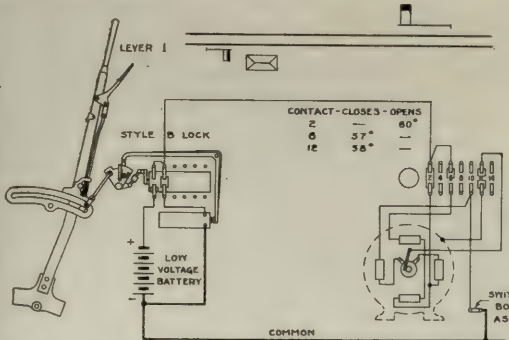


Fig. 2053. Model "2A" Non-Automatic Signal Operated from Mechanical Interlocking Plant. General Railway Signal Company.

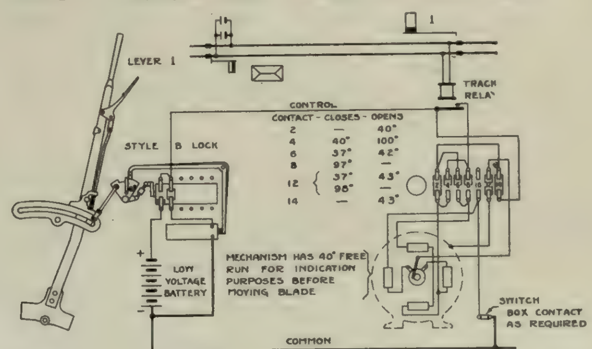


Fig. 2054. Model "2A" Semi-Automatic Signal Operated from Mechanical Interlocking Plant. General Railway Signal Company.

signal location. The signal mechanisms used with circuits shown in Figs. 2053 and 2054, with the exception of the motors, are shown in Figs. 1814-1815 and 1818-1819 respectively. The release effected by the dynamic indication is received and stored by a suitably arranged style B lock, with which the controlling lever is equipped. The generation of placed at stop, if for any reason the lock on the distant lever should not be released thereby preventing the distant lever from being latched in the full normal position; the home lever, however, may not be placed full normal and the route consequently may not be released until the proper indication has been received.

ELECTRIC LOCKING.

In a mechanical interlocking plant there are detector bars to prevent switches being thrown while a train is upon them, and they have been a safety device of great value. But the only check on the manner in which the signalman handles his levers at such a plant is the dog locking and the detector bars, and with moderate speed of trains and a high intelligence in signalmen nothing more could be desired. But speeds have been increased to such an extent that distant signal indications must be given farther away, and power has been introduced to work switches and signals.

Increased speed means more space to stop in, and with the simple mechanical plant there is nothing to prevent a signalman from changing the route after a train has passed the distant signal at clear; this might lead to running a train off the high-speed routes. For example, suppose that the switches are set up for the route from A to B, signal 17 cleared, and a train is on some part of this route. Then the latch on lever 17 is locked so that it cannot be lowered in the normal position (and in consequence of this no locking will be released) until the train has passed signal 4; 17 reversed locks 9 reversed, which locks 10 reversed; also 17 reversed locks 7 reversed, which locks 8 normal; also 4, 20 and 18 are locked

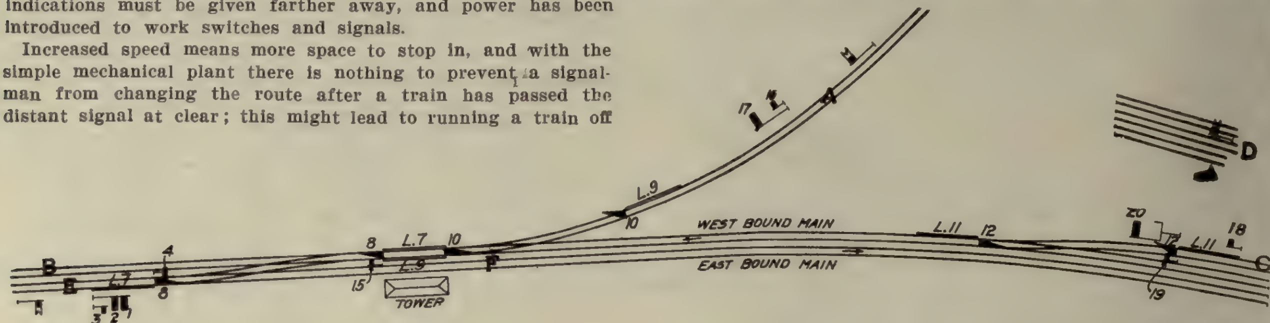


Fig. 2055. Interlocking, Single and Double Track Junction.

a derail or through a sharp turnout at high speed, with disastrous results. Power used to operate switches has frequently crumpled up detector bars under trains. With rail larger than the 85-lb. section the ordinary outside detector bar cannot be counted upon to strike the tread of the wheel, and inside detector bars (Figs. 1480 and 1598-1603) for various reasons are not considered desirable. Thus a switch or derail may, under certain conditions, be thrown under a moving

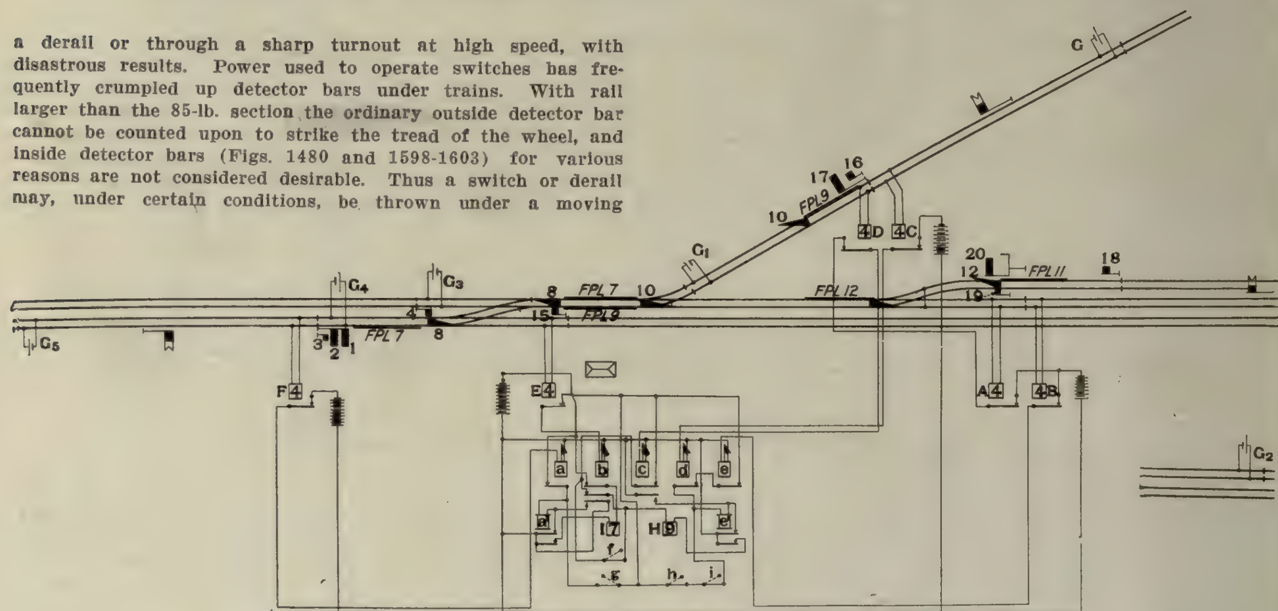


Fig. 2056. Electric Locking for Switches and Signals Shown in Fig. 2055.

train. Furthermore, detector bars, as usually installed, are operated on a false principle; if they fail, they are inoperative. To overcome these and other difficulties, electric locking has been introduced. It may be considered an extension of the functions of the track circuit, and in some methods of application is called track circuit locking.

As applied to mechanical interlocking it is usually quite simple. It involves only the use of electric locks (Figs. 2801-2812) on the latches of certain levers, usually those of the home signals; although, if the protection is to be made more complete, they are applied to certain special route levers or to regular levers that can be used as route levers.

These locks are controlled by circuits passing through the contact points of track relays in the various sections involved. This control is usually accomplished through the medium of an indicator (see page 363); that is, the track relays control the indicator, and the indicator controls the lock. This is done in order to give a visual indication of the condition of the track section and not compel the signalman to depend upon watching the train or trying his levers. Repeated trials will in time wear out the dog and the slot of the lock. The relative protection afforded by locking signal levers and route levers, respectively, may be understood by reference to Fig. 2559, which shows the layout of an interlocking plant having a twenty-lever machine. If the latches of high home signals only are controlled by track circuits, protection will be given only to trains moving in the established direction of traffic on normal; therefore, it is safe for the train to proceed, as none of these functions can be moved. But suppose that the signals are set for a movement from B to A; now 4 reversed will lock all the conflicting and opposing functions, but it has no lock on its latch, and therefore no track circuit protection. This could be overcome by putting locks on all the dwarf signal latches, but this is considered too expensive. Also if the signal were out of service and the signalman should flag a train through without reversing his signal lever, there would be no protection.

Full protection can be provided at minimum expense by choosing certain levers as route levers and locking their latches. There are the following possible routes in the present case: A-B, C-D, D-B, A-E, C-E, D-E, E-F, B-A, B-C, B-D, E-A, E-C, E-D, F-E. These routes may be so grouped together that from A to all possible points can be considered as one route; the same for B and E. Now, if the dog locking is arranged so that in setting up a route to or from A or B, 9 must be thrown last before the signal, and to or from E, 7 must be thrown last before the signal, then 9 or 7 reversed will lock all the functions in the route and will in turn be locked by the signal lever. Therefore, levers 9 and 7 are the only ones whose latches need be supplied with locks. These locks must lock the latch down with the lever reversed. This must be done every time a derail or lock lever is used as a route lever. Frequently when a switch lever is used as a route lever the lock must lock the latch down with the lever either normal or reversed. When so supplied protec-

tion against improper movements of switches and derails is afforded without reference to the home signal levers, no matter what route is being used. Whenever a lock is placed on a signal lever it should never hinder moving the lever far enough *to* cause the signal to assume the stop position (or caution position in case of a distant signal), because it should always be possible to move the lever to stop a train in case of emergency.

Another method is to have the home signals locked as soon as cleared, and released only when a train has reached a certain point within or beyond the interlocking limits. This will be discussed later in connection with approach locking.

At power plants with electric control the same methods as above described may be used; that is, electric locks on the levers may be used. Usually there are no latches or latch locking at these plants, consequently the lever itself must be locked. Another difference is that there are usually no separately operated facing point locks at power plants; therefore a derail or switch lever must be used for the route lever, and be controlled by the electric locking. If signal levers are to be locked it is often convenient to break their indication circuits through relay or indicator contacts, thus avoiding the necessity of an additional electric lock. Also with the same effect, the control circuits of switches and derails are broken through such contacts.

If the indication circuit of all signals concerned is broken while a train is occupying the route or section of route governed, the protection will be complete. For when the indication circuit is broken, the releasing device on the lever cannot act, and the lever is held in an intermediate position, thus locking all opposing and conflicting routes as if it were at full reverse. Usually, however, the indication circuits of the high home signals only and the control circuits of the switches and derails in a route are broken. This is done, because if, with no means of holding the switches, a signal should be out of order, and it were necessary to flag a train through, there would be no protection; this for the reason that there would be nothing to compel the signalman to reverse his signal lever, and with the signal lever normal the route would not be locked. The best system would seem to be a combination of lever locking and circuit control; that is, to break the high home signal indication circuits and the switch and derail control circuits and lock route levers.

In another system of electric locking, conflicting routes only are locked; that is to say, a train in a certain route locks switches and derails in conflicting routes only. This is no more than dog locking is designed to do, except that it holds after the signal lever has been put normal, until the route is clear.

At power plants controlled otherwise than electrically, lever locking is the only kind that can be economically and efficiently applied. Valves and their controlling apparatus are cumbersome and expensive.

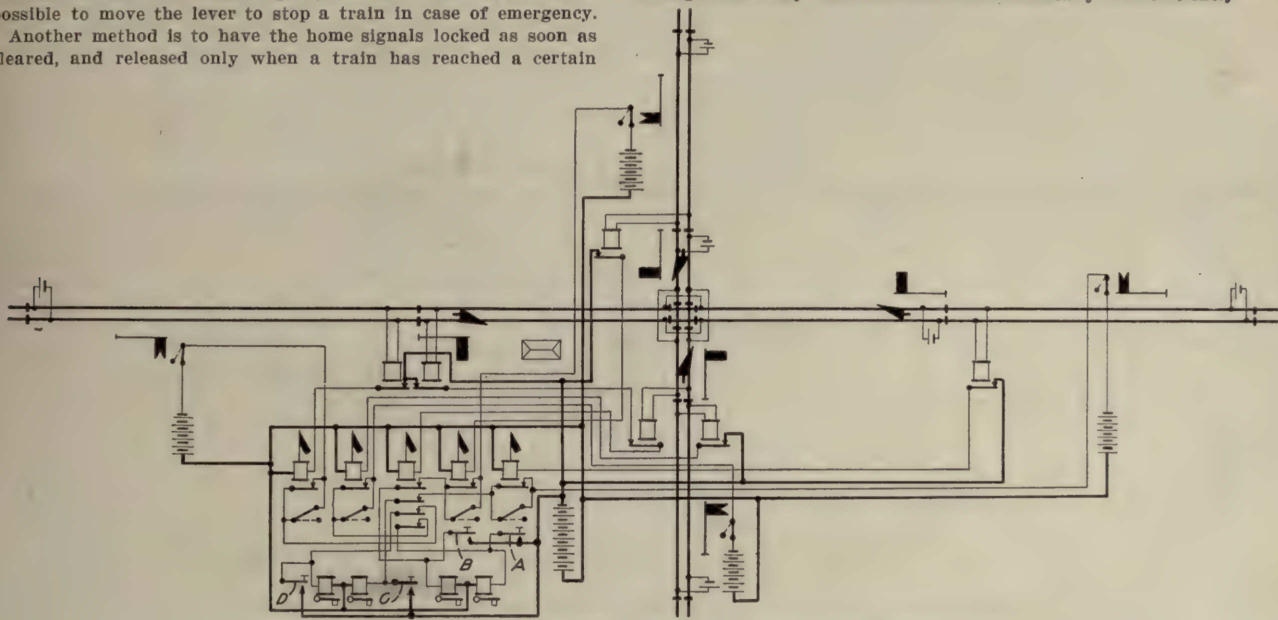


Fig. 2057. Electric Locking Circuits for Single-Track Crossing.

Where any one of these systems is applied only to track sections within the home signal limits the use of detector bars can hardly be dispensed with. It takes an appreciable length of time for a track relay to act, and the indicator and lock consecutively consume equal periods. Therefore, before the lock has acted it may be possible to change at least one of the switches or derails in the route. Consequently, it is advisable to have a detector bar at the entrance to each high-speed route, at least.

To overcome this difficulty and to better prevent any change of route after a train has passed the distant signal at clear, approach locking has been introduced. This is an arrangement of circuits whereby the lock on the home signal or route lever latch operates when a train approaches the interlocking plant with the governing signals in a certain position.

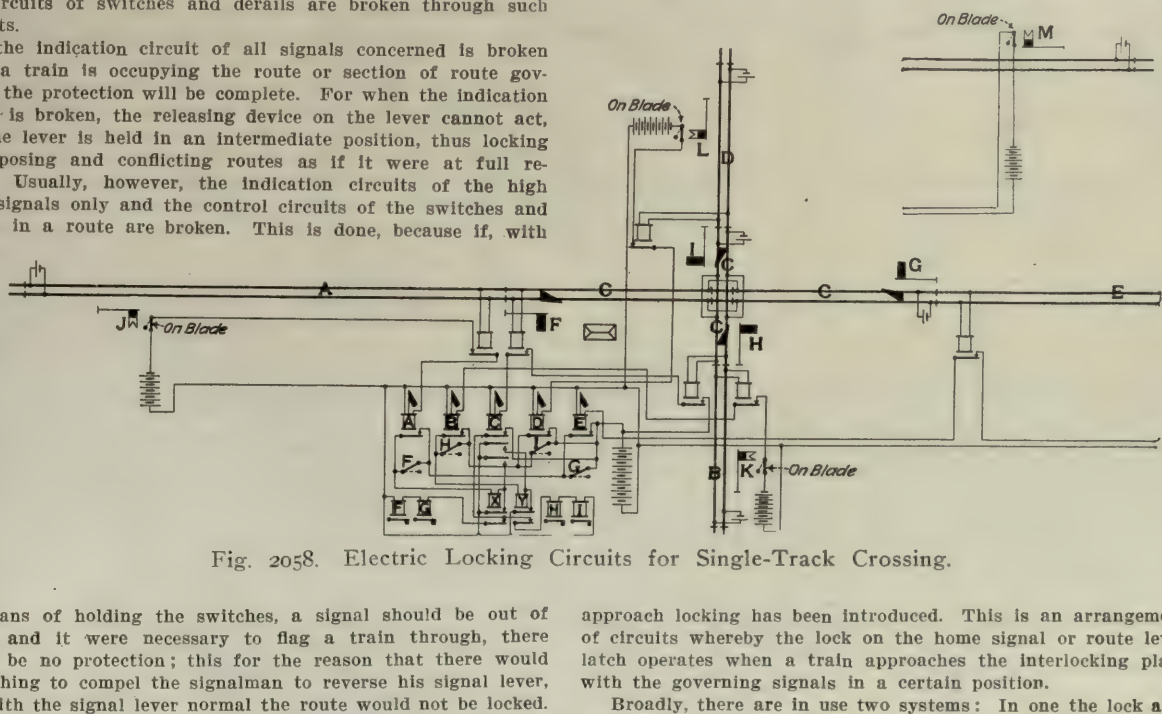


Fig. 2058. Electric Locking Circuits for Single-Track Crossing.

Broadly, there are in use two systems: In one the lock acts as above when the train is approaching the distant signal with the home signal clear, and holds until the train has reached a point within or beyond the interlocking limits. This may be modified so as to require the distant signals also to be clear; or it may be made to act when a train has passed the distant

signal with the home signal clear. In the other system, the route is locked as soon as the home signal is cleared, regardless of whether a train is approaching or not. Of course, in dealing with electrically controlled power plants the above may be modified so as to break control and indication circuits as already described.

Fig. 2056 shows the approach and other locking circuits for the mechanical interlocking plant shown in Fig. 2055. The system is that described for Fig. 2055, using 7 and 9 as route levers, and the first of the approach locking systems.

A, B, C, D, E and F are track relays operated by batteries G, G_1, etc., through their respective track sections; a, b, c, d and e are indicators; a is controlled by F, b by E, c by A and D, d by C and e by B. H is a lock on the latch of lever 9, and I is a lock on latch of lever 7; f, g, h and i are circuit controllers operated by levers 8, 2, 17 and 20, respectively. Suppose a train to be approaching on the branch line with the route lined up. Until the first track battery G is passed the route can be changed at will, but as soon as G is passed relay C opens, thereby de-energizing indicator d, relay e′ and lock H. For, when No. 17 was reversed, circuit controller h was opened and the shunt on the point of d and e removed. Thus lever 9 is locked reversed and the route cannot be changed. Lever 9 remains locked until the train has passed beyond signal 4, as by its passage relays D and A are successively opened, thereby de-energizing indicator c. This keeps the circuit for lock H open. The signalman is prevented from restoring his lock (by putting his signal levers normal) while a train is approaching by the special stick wiring of the relays a′ and e′ which control the locks with the "home" indicators b and c. They are controlled by the approach indicators a, d and e, and break their own circuits. They can be restored only through the back contacts on their respective home indicators when a train is in the home section. Suppose the train approaches without the signals clear; in this case the route would not be locked and the signalman could hold the train at the home signal until ready for it to proceed. At the same time he could allow another train to use any of the routes within the plant. The purpose of circuit controller f on lever 8 is this: Suppose that the route through the crossover reversed is set up for an eastbound movement. Now, to be safe, lever 9 must be controlled by relay E (through indicator b); otherwise it would be possible to move any of the switches except the crossover, until the train had passed through the crossover, onto the track circuit controlling relay A. Therefore f is made to break the shunt around the contact point of indicator b in the circuit of lock H. Lock H cannot be controlled by this indicator in all cases, because if this were done a train on the eastbound track would prevent changing a route on the westbound track, when it would be proper to do so.

One modification that is frequently made is to put the circuit controllers on the distant signal levers. When this is done the approach locking takes effect only when the distant signal is clear with a train approaching. In the plant under consideration the distant signals are assumed to be power operated without separate levers. Sometimes the circuits for the approach indicators are broken through normally closed circuit controllers on the home and distant signal arms, so that if either should fail to assume the full stop position when the levers are put normal, the route would remain locked.

Fig. 2057 shows the circuits for approach and other locking at a single track crossing. Here a separate circuit is run for each lock through circuit-breakers on the distant signals, so that the locking will not release until the distant signal arm is in full horizontal position. The locks act on the latches of the home signal levers to which are also attached the shunt circuit controllers (shown just beneath the indicators). These circuit controllers are closed only when the levers are normal and the latches down. The contacts A, B, C and D represent hand releases (usually some form of time-release, Figs. 2843-2853) which are used when it is necessary to change a route that has been given to a train.

Fig. 2058 shows the same crossing wired with the indicator circuit through a circuit controller on the distant signal arm. Here the approach indicator contact opens when the distant signal is cleared, whether a train is approaching or not. The locks act as in Fig. 2057, but the circuit controllers F, G, H and I need not be attached to the latches. They can work with the home signal levers. The stick relays, X, Y, hold the lock circuits open during the passage of a train, whether the signal levers are restored or not. These circuits are suitable for a power plant in which control and indication circuits are broken, and there are no locks on the levers. At such a plant stick relays are necessary (as there is no latch locking), unless the section of lever stroke, after indication has been received, is long enough to operate a circuit controller. At a plant where the home signal lever latches are locked stick relays are not needed, as the shunt circuit controller can be made to be closed only when the lever is normal with the latch down, as in Fig.

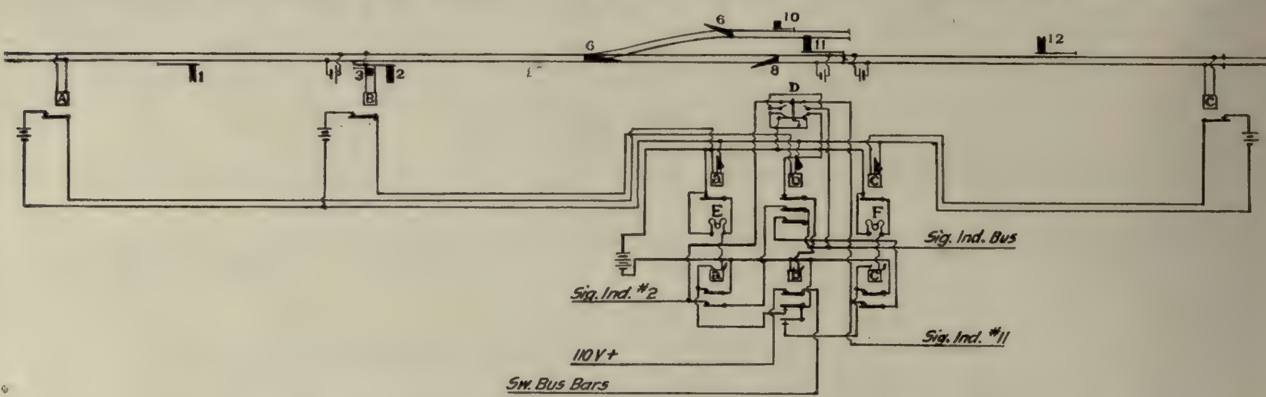


Fig. 2059. Approach Locking for Single Switch on a Single-Track Main Line.

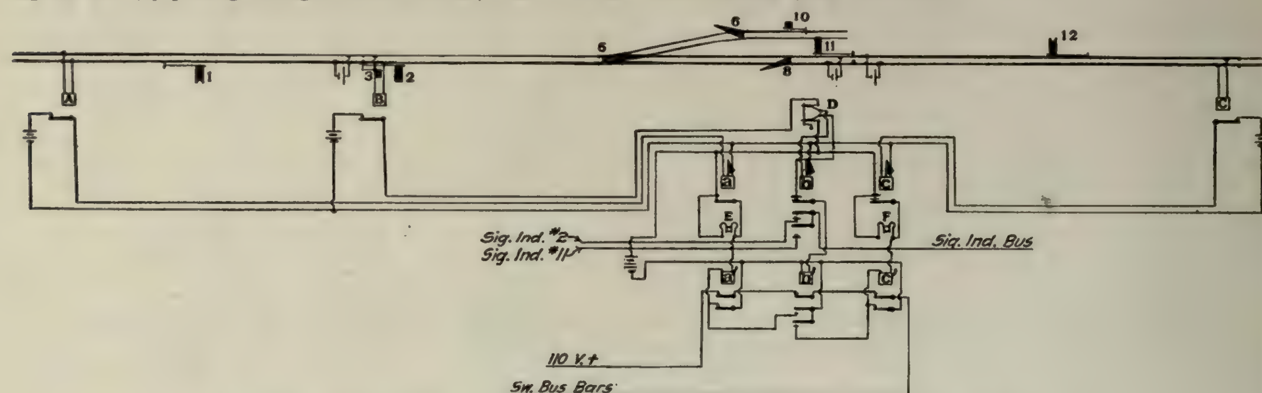


Fig. 2060. Approach Locking for Single Switch on a Single-Track Main Line.

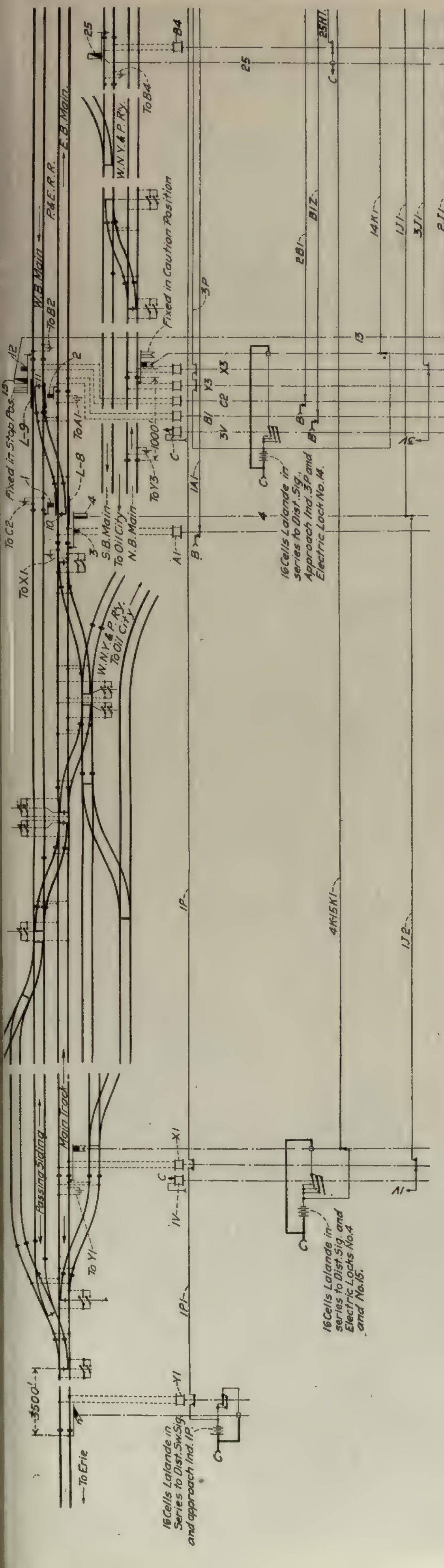


Fig. 2061. Electric Locking Circuits, Irvineton. Pennsylvania Railroad.

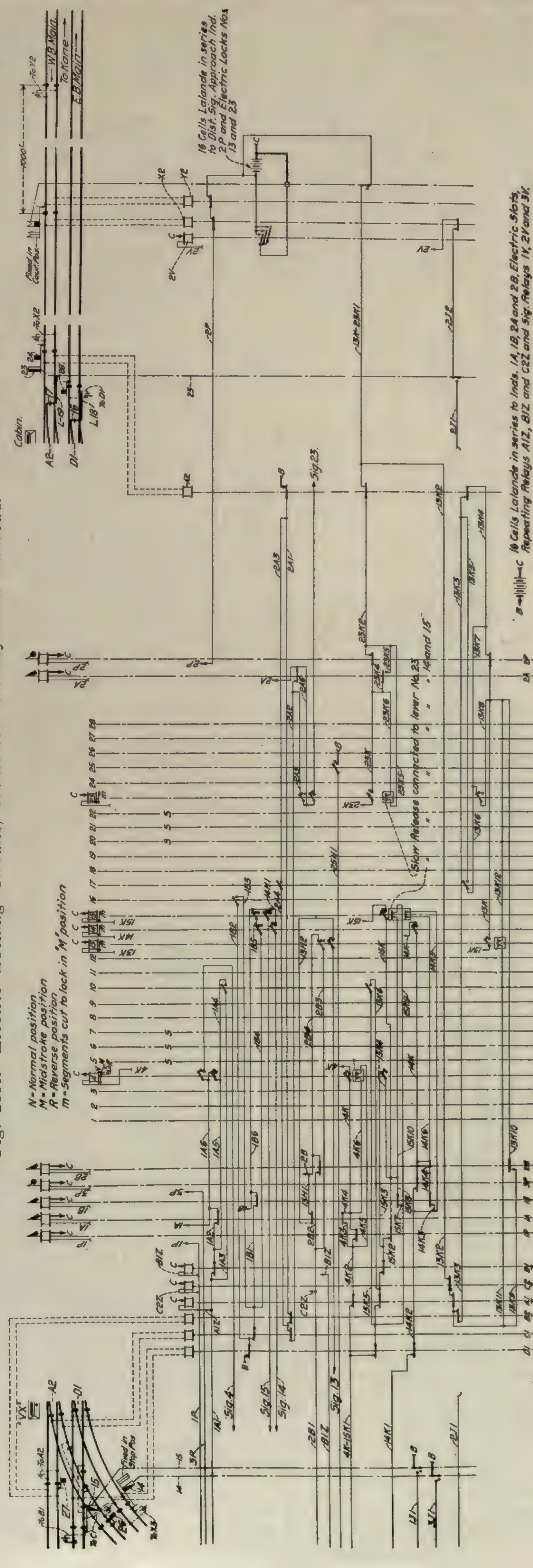


Fig. 2062. Electric Locking Circuits, Irvineton. Pennsylvania Railroad.

2057, and this condition will not occur until the lock is released. At power plants the point at which the lever is held for indication can sometimes be used as the latching point, as above. But in any case where the shunt circuit controller is operated by a lever other than the one upon which the lock acts, a stick relay must be used.

In a power plant using the first modification described for Fig. 2056, but without lever locks, indicators are provided, controlled by track circuits in the usual manner, as shown in Fig. 2059. In this diagram A, B and C are track relays; a, b and c indicators, a′ and c′ stick relays, b′ a secondary relay controlled by indicator b, and E and F, contacts on distant signal levers 1 and 12 respectively. The approach locking is accomplished by breaking the indication circuit of the home signal governing the route, through the front point of the stick relay, controlled by the circuit controller on the distant signal lever in parallel with a front point on the approach indicator. In this system, unless the distant signal has been cleared, it is possible to put a home signal lever normal at any time, provided a train is not in the section governed. This does away with delay in case the wrong route has been lined up. The stick relay is restored by a back contact on relay b′. With this system there is no delay due to the locking in case the signalman neglects to put his home signal lever normal promptly behind each train. When the distant signal is cleared with a train approaching, the home signal indication is withheld until

NOTE TO FIGS. 2063-2068.

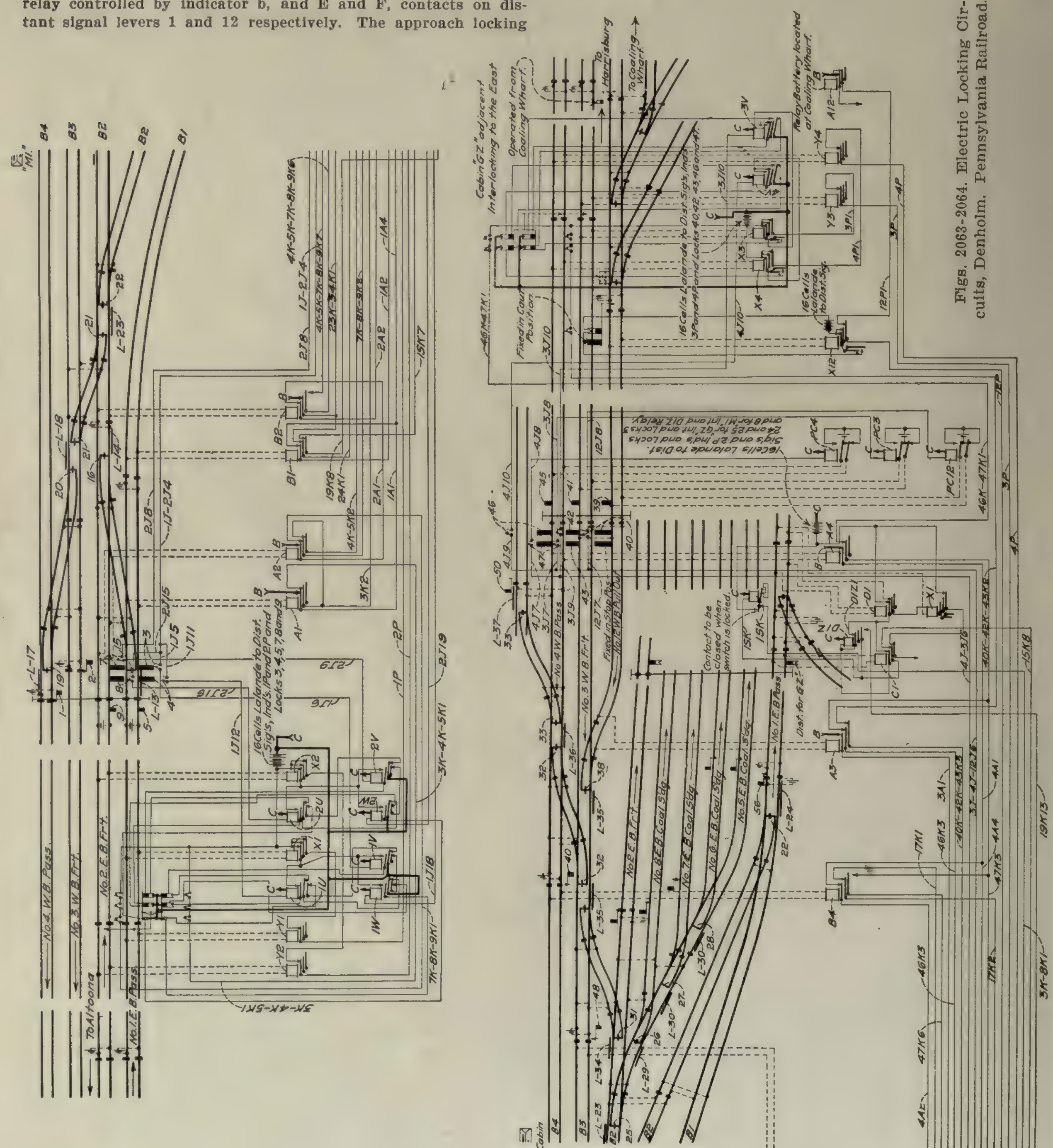
Insulated switch rods to be used on all switches in track circuit limits.

Insulated connections to be used on all detector bars.

Resistances:

Indicators	1000 ohms
Repeating relays	1000 ohms
Electric locks	500 ohms
Electric slots	100 ohms
Track relays	5 ohms

Indicator and relay symbols:



Figs. 2063-2064. Electric Locking Circuits, Denholm. Pennsylvania Railroad.

1A, 2A, etc.—Block indicators.
1P, 2P, etc.—Approaching indicators.
A1, X2, Y1, etc.—Track relays.
1V, 2V, etc.—Signal relays.
A1Z, B1Z, etc.—Repeating relays.

Wire numbering, these symbols indicate things controlled:

Track Nos. 1A-2A, etc.—Block indicators.
" " 1P, 2P, etc.—Approach indicators.
" " 1J, 2J, etc.—Distant signals.
" " A1Z, B1Z, etc.—Repeating relays.
" " 1SK—Electric lock on hand switch.

Lever Nos. 4K, 14K, etc.—Electric locks.

The consecutive wire number follows the letter of the symbol (the last letter in combined symbols).

the train has passed out of the home section. The current supply to the switch bus bar is cut through a contact on relay b′ in order to provide detector locking for a movement from

The second system, wherein the home signal is locked as soon as its lever is reversed, is used more extensively at power plants electrically controlled (see Fig. 2076). In this system

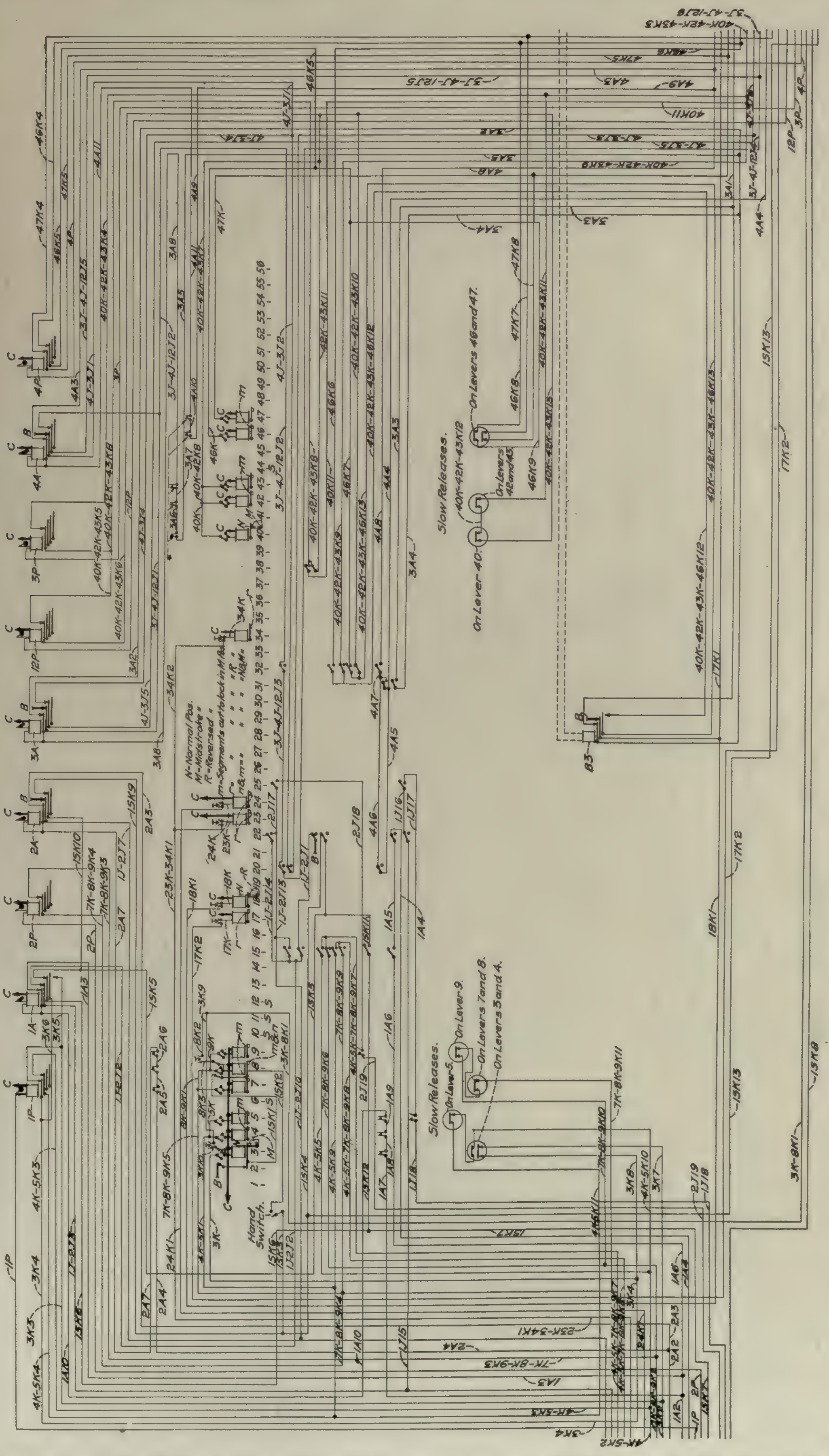


Fig. 2065. Electric Locking Circuits, Denholm. Pennsylvania Railroad.

(Note. Figs. 2063-2065. Are Parts of a Single Diagram. The Track Plan, Figs. 2063-2064, is Divided Opposite the Tower and the Wiring in the Tower is Shown in Fig. 2065.

signal 10. With this system signals can be tested at any time without necessitating the use of the hand release.

the indication circuits of the home signals are normally broken through open back points of indicators, controlled by the home

track circuits, so that the stroke of the signal lever to normal cannot be completed without using a hand release unless a train occupies the track section. In other words, if the signalman clears a home signal, he cannot completely restore his as shown in Fig. 2060. In this figure indicators a, b and c are controlled by track relays A, B and C, respectively, a' and c' are stick relays, b' is a secondary relay controlled by indicator b, and E and F are circuit controllers on the distant signal

Fig. 2066. Electric Locking Circuits, North Philadelphia. Pennsylvania

Note. Figs. 2066-2068 Are Parts of a Single Diagram. The Track Plan, Figs. 2067-2068 is Divided Opposite the Tower and the Wiring in the Tower is Shown in Fig. 2066.

lever in the usual way unless a train is within the interlocking limits on the track governed. Additional approach locking is accomplished by breaking the power circuits of the switches and derails in the route governed through points on stick relays, levers. The stick relays are controlled by the circuit controllers on the distant signal levers, in parallel with the front points of indicators, a and c, which are in turn controlled by the approach track circuits. The stick relays are restored by

Figs. 2067-2068. Electric Locking Circuits, North Philadelphia. Pennsylvania Railroad.

back contacts on relay b. The current supply to the switch bus bar is controlled by all three relays, a′, b′ and c′, providing electric detection. Hand releases D are provided in Figs. 2059-2060 for use, as explained in connection with Figs. 2057 and 2076. To compel the signalman to restore the release to its normal position after reversing it, the return for relay b′ is in each case cut through a normal contact on the hand release.

Some disadvantages of locking the route by reversing the signal levers, regardless of whether or not a train is approaching, are as follows: 1. It is impossible to test signals easily. Every time the lever is reversed it locks itself. This is particularly annoying at mechanical plants in winter, when it is necessary to move the signals frequently to keep them from freezing. 2. It interferes with the flexibility of operation. If

of relay B4, wire 47K6, to wire 47K. This also cuts out the front contact of indicator 4P when relay B4 is de-energized. The lock is de-energized with train in approach, distant or home track section, also with the distant signal clear, and is not again energized until train has entered section B4, since relays Y4 and X4 control the indicator 4P. The object of the back point on relay B4 is to allow the signalman to put lever 47 normal, supposing one train is standing in section A4 and another train in either the approach or distant sections. If the first train should pass to section B4, it would be proper to let the second train through crossover 32 onto track 3, but the indicator 4P would be de-energized and therefore this back contact on relay B4 is necessary to permit the route to be changed. The slow release also acts as a shunt around the contact on indicator 4P. It should be noted that the slow

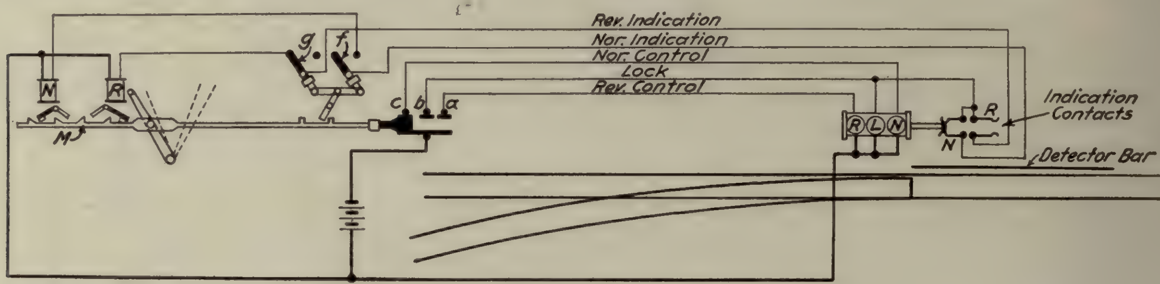


Fig. 2069. Circuits for Electro-Pneumatic Switch Movement Without Detector Locking.

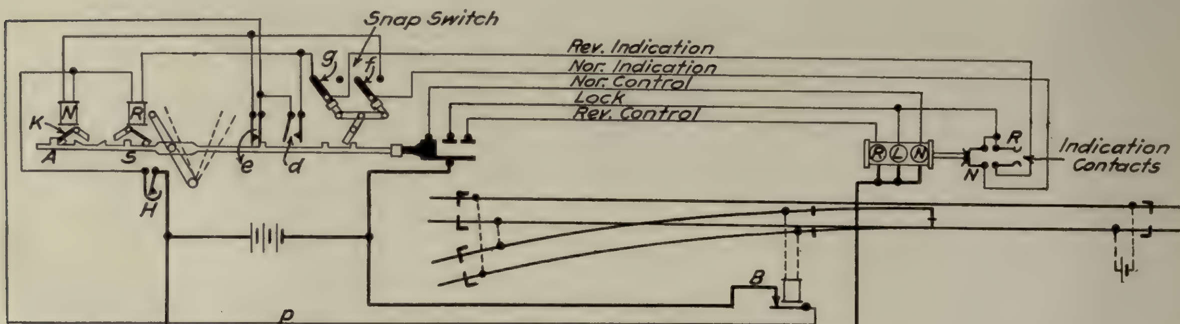


Fig. 2070. Circuits for Electro-Pneumatic Switch Movement With Detector Locking.

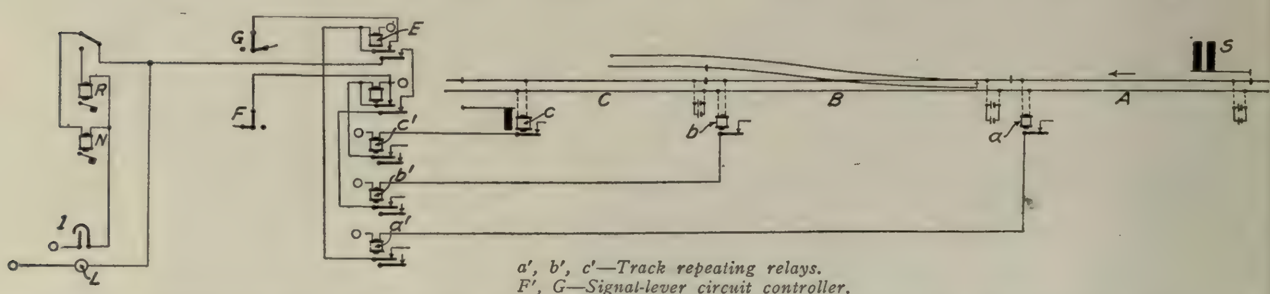


Fig. 2071. Typical Route and Detector Locking Circuits for Electro-Pneumatic Interlocking Plant. Delaware, Lackawanna & Western.

the wrong route is lined up by mistake, it locks itself, thereby causing delay.

It will be observed that circuits for the control of routes are so arranged that if any part of the apparatus should fail or become deranged, the locking would act and hold the route, or possibly the whole plant, locked until the trouble is repaired. This is the governing principle in signaling. If anything fails, a dangerous condition must not result.

Figs. 2063-2065 show electric locking at Denholm, on the Pennsylvania Railroad. This is a mechanical interlocking plant. The locking circuits for the route governed by signal 47 may be considered as typical. Circuit for lock 47: From battery at distant signal through circuit breakers on signal arms, wire 46K-47K1, front point of relay A4, wires 47K3 and 47K4, from point of indicator 4P, wires 47K5 and 47K, circuit breaker on tappet, through lock to common. A branch 47K7 is taken off wire 47K3, through slow release to wire 47K, thereby cutting out the contact on indicator 4P with instruments in normal position. Another branch is taken off wire 47K3 to back point

release and the back contact on relay B4 are inoperative with a train standing in section A4, in other words they act only on the approach locking. The track circuit in section A4 is a detector circuit inasmuch as it locks the latch of lever 47 up with the lever normal, thereby preventing movement of any of the switch or facing point lock levers for the route governed up to signal 40. Relays B4 and B3 control a lock on facing point lock lever 17, locking this lever reversed. This acts as a detector lock when a train is standing in either circuit.

Figs. 2061-2062 show electric locking circuits in use at Irvineton, Pennsylvania Railroad.

This is a mechanical interlocking plant with slotted signals. The circuits for route governed by signals 23 and 13 may be considered as typical. The circuit for lock 23 starts from the battery at right of Fig. 2062, and passes through the circuit controller on the distant signal, wire 13K-23K1, from contact on relay A2, wire 23K2, front contact on indicator 2P, wire 23K, circuit controller on tappet (lever 23), lock 23 to com-

mon and back to battery. Two parallel circuits are run around the front contact on indicator 2P, one through the back point on indicator 2A, the other through the slow release.

The circuit for indicator 2P starts from the same battery and passes through the front contacts of relays Y2 and X2, wire 2P, indicator 2P, to common.

The circuit for indicator 2A starts from the main battery and passes through the front contact of relay A2, wire 2A1, front contacts of relays B2 and C1, wires 2A2 and 2A5, circuit controller on lever 23, wires 2A6 and 2A, indicator 2A to switch 17 reversed, while another train is standing between signals 27 and 13. A tap is taken off from wire 2A6, through the second circuit controller on lever 23, to the slot on signal 23 (not shown).

Lock 23 is de-energized with a train in the approach, distant or home circuits, or with distant signal clear. It should be noted that indicator 2A is controlled beyond the limits of section A2 and that its back point picks up the lock, provided the distant signal is normal and no train is in the home circuit, A2. This indicator remains de-energized until lever 23

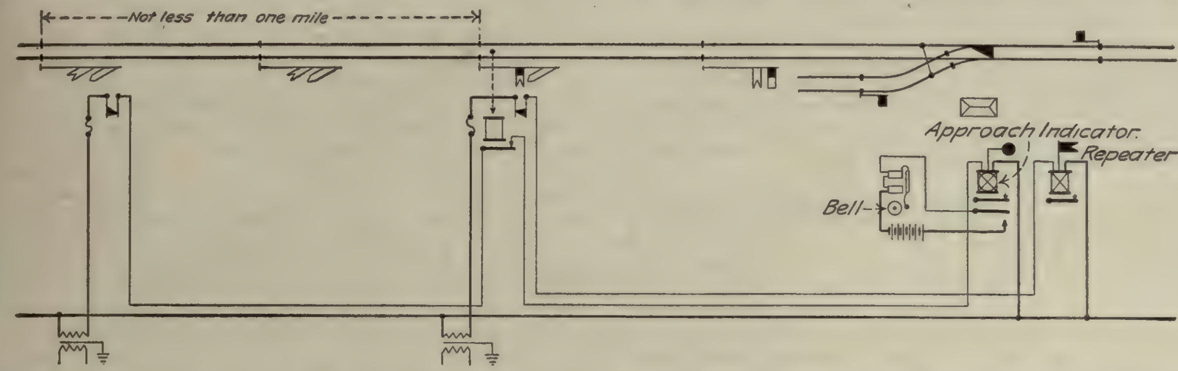


Fig. 2072. Typical Circuits for Approach Indicator and Distant Repeater (Automatic Signals are Overlapped). Electric Zone, New York Central & Hudson River.

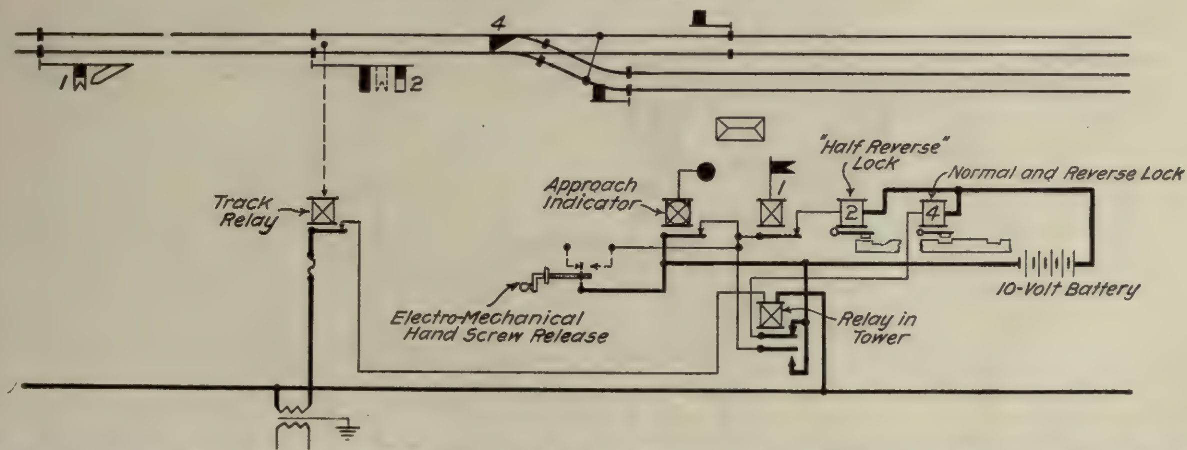


Fig. 2073. Typical Circuits for Approach Locking and Electric Detection at an Electric Interlocking Plant. Electric Zone, New York Central & Hudson River.

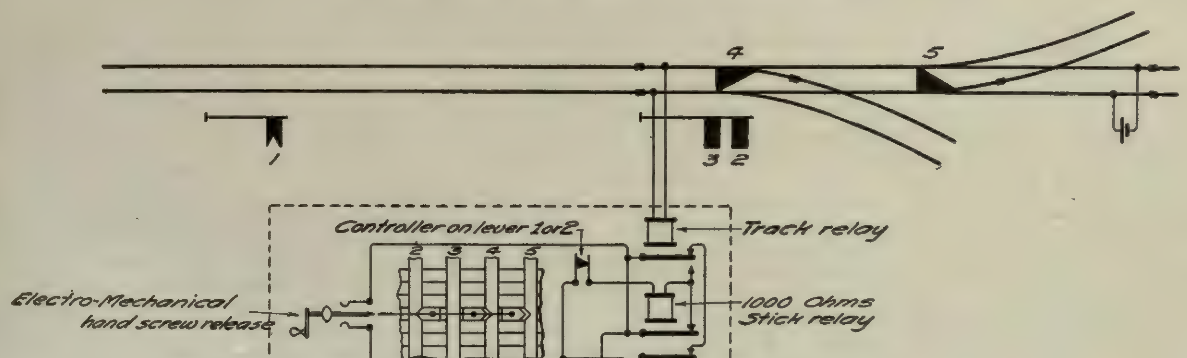


Fig. 2074. Electric Locking Circuits, With Electro-Mechanical Hand Release for Electric Interlocking Plant.

common. As soon as the indicator is energized its front armature contact forms a shunt direct from wire 2A2 to 2A, so that the indicator will remain energized after the circuit controller on lever 23 is opened, in the same manner as a stick relay. This "stick" feature makes it necessary for lever 23 to be put into the full normal position after each train. A shunt circuit through wire 2A3, circuit controller on lever 17, and wire 2A4, bridges the contact on relay B2 when 17 is reversed. This is to allow a train to be moved from signal 23 through is fully normal. This extends the releasing section, giving the signalman more time to restore his lever after a train passes, in case a following train has entered track circuits Y2 or X2, and is to proceed on a different route. Leaving the signal lever reversed will not cause trouble, because the slot circuit is then de-energized and the signal will remain in the stop position until the lever is put normal and again reversed.

The lock on lever 13 is controlled through wire 13K2, which taps off from wire 13K-23K1, in substantially the same manner

as lock on 23. Thus the advance and home signal lever latches are both locked up (lever normal) if these signals have been cleared for an approaching train. The slow releases perform the same function as the back point on the home or advance indicators.

Figs. 2066-2068 show electric locking circuits at North Philadelphia, Pennsylvania Railroad. This is an electro-pneumatic plant. Both approach and detector locking is provided. The approach locking and release circuits are similar to those shown for Irvineton (Figs. 2061-2062). Locking of levers is accomplished through the indication magnets. The track circuits are supplied with current from storage cells. The detector locking is accomplished as shown in Fig. 2070 by breaking the switch lever circuits through track or repeating relays, or indicators for the sections in which the switch occurs. The circuit for switch 5 shows the simple arrangement; most of the other switches are provided with route locking controlled through stick relays; No. 9 may be considered as typical.

In electro-pneumatic interlocking for indication purposes a switch lever is unlocked near the end of the stroke to allow a movement to the extreme position, whereas for electric detection the lever is unlocked to allow a movement starting from the extreme position. As these two lockings are never required at the same time they can, in the electro-pneumatic machine, be secured by use of the same apparatus through a modification of the lock segment and latch, and an addition to the circuits controlling the normal and reverse indication magnets.

The standard form of segment is shown in Fig. 1964, and *d* is closed. In the extreme normal position, as shown in the diagram, the only current that can energize N must pass through the contact on the track relay and similarly, with the lever in extreme reverse position, current for R must pass through the same relay contact and controller *d*. The circuit breakers *e* and *d* are the same as the roller band controllers employed for signal circuits. The dog S engages with the armature of R when the lever is reversed in the same manner as A with K when normal.

Fig. 2071 shows typical electric locking circuits used at the Hoboken Terminal of the Delaware, Lackawanna & Western, which provide route locking and also electric detection. The track is divided into convenient sections between signals so as to allow maximum freedom of lever movements; *a*, *b* and *c* are track relays for circuits A, B and C, respectively. Each of these track relays controls a repeating relay, *a′*, *b′* and *c′*, which simply repeat the action of the track relays. Relays *a′* and *c′* control stick relays in connection with the circuit controllers F and G, on the signal lever. Suppose a train to be approaching signal S; to permit it to proceed the signalman reverses the signal lever to the left, opening circuit controller G, but keeping F closed. As soon as the train enters section A relays *a* and *a′* are de-energized; when *a′* opens (G already being open) stick relay E is de-energized, opening the circuit for the lock magnet N on the switch lever. As the train passes from section A to section B the relay *b′* is de-energized, holding the circuit for lock N open. Relay E picks up as soon as the rear of the train clears section A. When the train enters section C, relay *c′* opens, but as F is still closed the stick re-

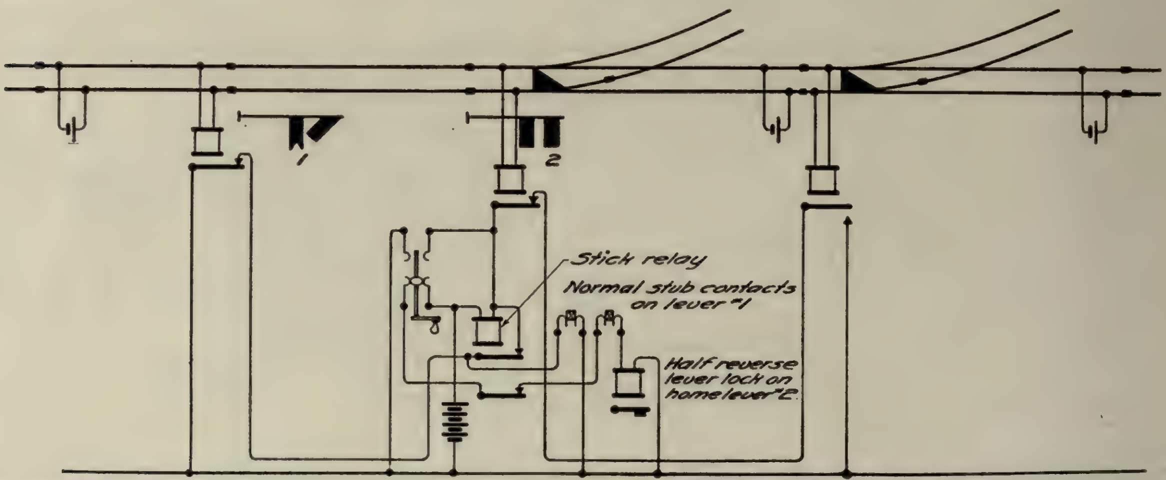


Fig. 2075. Typical Electric Approach Locking Circuits, With Electric Hand Release for Electric Interlocking.

its operation indicated in Fig. 2069. This differs from the elementary form shown in Figs. 1972-1975, in the use of the lug M engaged by the reverse indication armature when energized (and also one for the normal armature). In reversing the switch, the magnet R should remain de-energized until lug M passes the point where the armature of R could engage it. If for any reason (such as a cross in circuits, etc.) R should be energized improperly, its armature would engage with M and prevent further movement of the lever. This lug also operates to prevent an indication magnet from acting falsely through residual magnetism, and also from being blocked or "plugged" by a careless repairman.

The modified form of segment is shown in Fig. 1965 and its operation in Fig. 2070. The armature K of the normal magnet N engages one side of the dog A, with the lever in the extreme normal position; in other words, it engages for detector locking purposes the other side of the same dog which is engaged for indication purposes during a movement of the lever from reverse to normal. The additions to the circuit include the wires B and *p*, passing through a front contact on the track relay, and the lever circuit controllers *e* and *d*, a lever latch circuit controller H also being added for the purpose of reducing the consumption of the current when it is not required.

With the lever in the extreme normal position shown in Fig. 2070, the detector lock circuit starts from battery and passes through wire B, front contact on the track relay, wire *p*, circuit controller *e*, magnet N, latch contact H, to common; thereby energizing N, and raising K from engagement with A, which unlocks the lever. The first movement of the lever opens *e*; controllers *d*, *g* and *f* remain unaffected until last portion of the stroke, when *g* and *f* are reversed and lay (directly above relay *c′*) remains closed, and as soon as the rear of the train leaves section B, relays *b* and *b′* are energized, and the circuit for lock N closed. If the switch is reversed the lock R is in circuit instead of N (see Fig. 2070). In a movement in the opposite direction the lower stick relay would be de-energized and E would remain energized. Thus circuits are provided to lock all switches in the route when a train passes the governing signal at clear. The switches remain locked until the train has passed over them or has backed off the route. Each switch is released as soon as a train has cleared the fouling point. Thus a route cannot be changed ahead of a train, but may be changed as soon as the rear of the train has passed. The contact 1 is operated by the switch lever latch in the same manner as H in Fig. 2070. The electric lamp L is connected in multiple with the lock magnets. It is placed just below the lever as shown in Fig. 2616, and is lighted while the switch is free to be moved, but it is extinguished when the switch is locked by the presence of a train.

For electric locking circuits used in connection with the electro-pneumatic push button machine, see Fig. 2003. For electric locking circuits for drawbridge protection, used with the electro-pneumatic interlocking machine, see Figs. 2014-2016.

In Fig. 2080 is shown an arrangement of electric locking circuits used at interlocking plants protecting simple crossings. The track circuit is normally open. The track battery supplies not only the track circuit, but also a 10-ohm stick relay whose circuit is carried through controllers on the home signal levers so that the reversal of any one of them will de-energize the stick relay. The stick relay cannot again pick up until all the home signal levers are normal and the track relay has been energized by the presence of a train. The stick relay and the

track relay both control, through a front and back contact, respectively, the circuit of the two electric locks which act on the derail levers. The circuits for these two locks are also carried through normally open floor pushes in order to economize in current. A push button is provided to energize the track relay and release the locking in case it becomes necessary to change a route that has been set up; but the push button will not release the locks unless the signals are all in the stop position. Fig. 2072 shows an approach indicator and distant signal repeater for an interlocking plant. In this case the exterior circuits are energized by alternating current. The approach indicator is controlled by a circuit from the transformer at the extreme left, through a normally closed circuit controller on the automatic home signal, the track relay point at the distant interlocked signal, the indicator, to common. A back point on this indicator closes a local bell circuit. The indicator circuit is not run through a circuit controller on the intermediate automatic signal because the circuits for these signals another is approaching. This relay is controlled by the home track relay. No provision is made for shunting out the distant repeater for the reason that should the distant signal stick clear a train might accept it and not be able to stop at the home signal. In such a case it would be dangerous to have any other than the high speed route set up. Lock No. 4 acts on the switch lever, locking it in either full stroke position. This lock is controlled by the repeating relay so that a train in the home circuit locks the switch in either the normal or reverse position, as the case may be. It is not released until the train has passed off the track circuit.

Another arrangement of circuits for approach locking is shown in Fig. 2075. Here, as in Fig. 2074, no indicators are used. The lock is controlled by a circuit controller on the distant signal lever, a stick relay, and the normal contact of the hand release. The stick relay is controlled by its own point and two parallel circuits, one through the approach track relay, the other through a second circuit controller on the distant

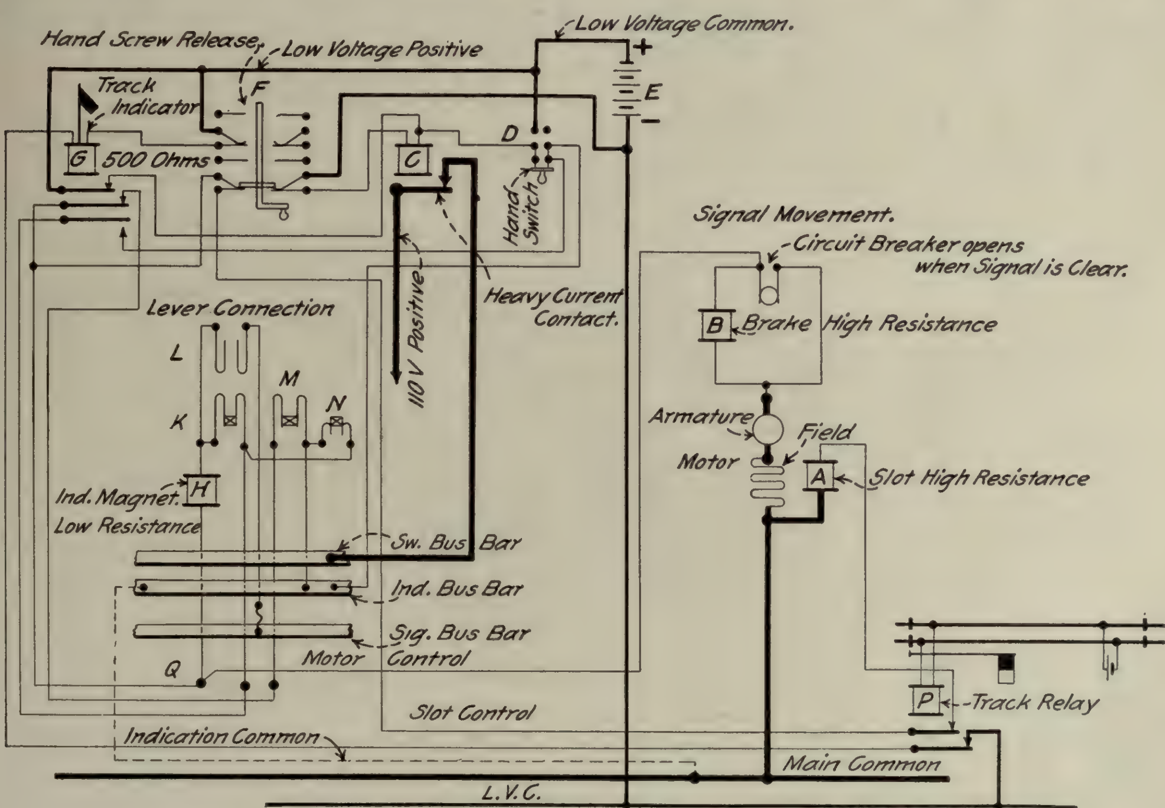


Fig. 2076. Typical Circuits for Electric Interlocking. Chicago & North-Western.

are overlapped. Therefore, the indication will be maintained for both sections by the one circuit controller. The repeater is operated by a normally closed circuit controller on the distant signal arm.

Fig. 2073 shows how the above instruments are made use of in approach and detector locking at an electric interlocking plant. The half-reverse lock (No. 2) holds the home signal lever against the indication stop when being moved to the normal position. This lock is controlled by the approach indicator and the repeater. If lever No. 2 has been reversed and the home and distant signals cleared, a train approaching within a mile of the distant signal will de-energize the lock and prevent lever 2 from assuming the full normal position. However, it may be moved far enough to put the signal at stop. It will be noticed that the notch is square on one side and sloped off on the other; this is to allow the lever to be reversed at any time. There are two shunt circuits around the contact of the approach indicator, one through the screw release, the other through the back point of the repeating track relay. Thus by working the release the approach indicator point can be shunted out. The mechanical action of this release will be considered in connection with Fig. 2074. It is to be used if a wrong route has been set up by mistake, and a train for another route is waiting at the home signal. The back point of the repeating relay performs the same function as the release when the relay is de-energized. This is to permit the lever to be fully restored to the normal position preparatory to setting up a new route, if one train has passed the home signal and signal lever. It is restored either by a back point on the advance track relay through front contact on the home track relay, or by the upper contact of the hand release. The lock is de-energized by the reversal of the distant signal lever. This opens one of the stick relay circuits also, so that a train in the approach section will open the stick relay. The stick relay will remain open until the train has entered the advance circuit. This circuit restores the lock, whether a second train is approaching or not, provided the distant signal lever has been put normal. With this circuit a route may be lined up and everything put normal again, provided no train is approaching, without using the hand release. This could not be done with the circuits in Fig. 2074. The release used in Fig. 2075 is entirely electrical. The first turns break the lock circuit while the last close the stick relay circuit. It is necessary to restore it to its normal position before the lock can pick up and the route be released. The lock is used to hold the signal lever in the "half reverse" position, as in Fig. 2073, so that the signal itself may be put in the stop position at any time in case of emergency.

Route and detector locking circuits for a General Railway Signal Company's electric interlocking plant are shown in Fig. 2076. The locking is secured by cutting the signal indication circuit, as explained in connection with Figs. 2059-2060, but on account of the "dynamic" indication current being present for only a short time after the signal mechanism has assumed its normal position, the circuit arrangement is somewhat different from that shown in these illustrations.

The switch bus bar is divided into sections, each section supplying current to the switches in one route only. Reversal of the signal lever energizes the slot A and clears the signal, through contacts L. The slot circuit is as follows: From the signal bus bar through contact L, indication magnet H, binding post Q, lower left hand contact on screw release F, upper contact on track relay P, slot magnet A, to common. If, after the signal is cleared, the lever is moved toward normal, the signal will go to the stop position and the dynamic indication current, generated by the signal motor, will flow through the main common, indication common, indicator bus, controller contacts M, indicator point, binding post Q, circuit breaker on signal, to motor. This will give no indication at the lever, but will act as a snubbing circuit to slow up the motor and prevent shock to the mechanism. If it becomes necessary to change the route after a signal has been cleared, the hand mon, indication bus, hand switch D, indicator back point, controller contact K, indication magnet H, binding post Q, circuit breaker on signal, to motor. This gives the indication and releases the lever. With the lever normal the indication circuit is kept closed through controller contact N in order to provide cross protection (pages 210-229). If for any reason indicator G should fail, it would keep relay C open and prevent the movement of any switches in the route. To move a switch under such circumstances hand switch D is reversed. This closes a local circuit for relay C, but opens the signal indication circuit. A switch can then be moved, but to get a signal indication D must be restored and this would again open circuit for C, thus preventing an improper movement. If the hand switch D should be operated while the screw release is reversed the relay C could not close because its return is cut through the lower right hand contact on the release.

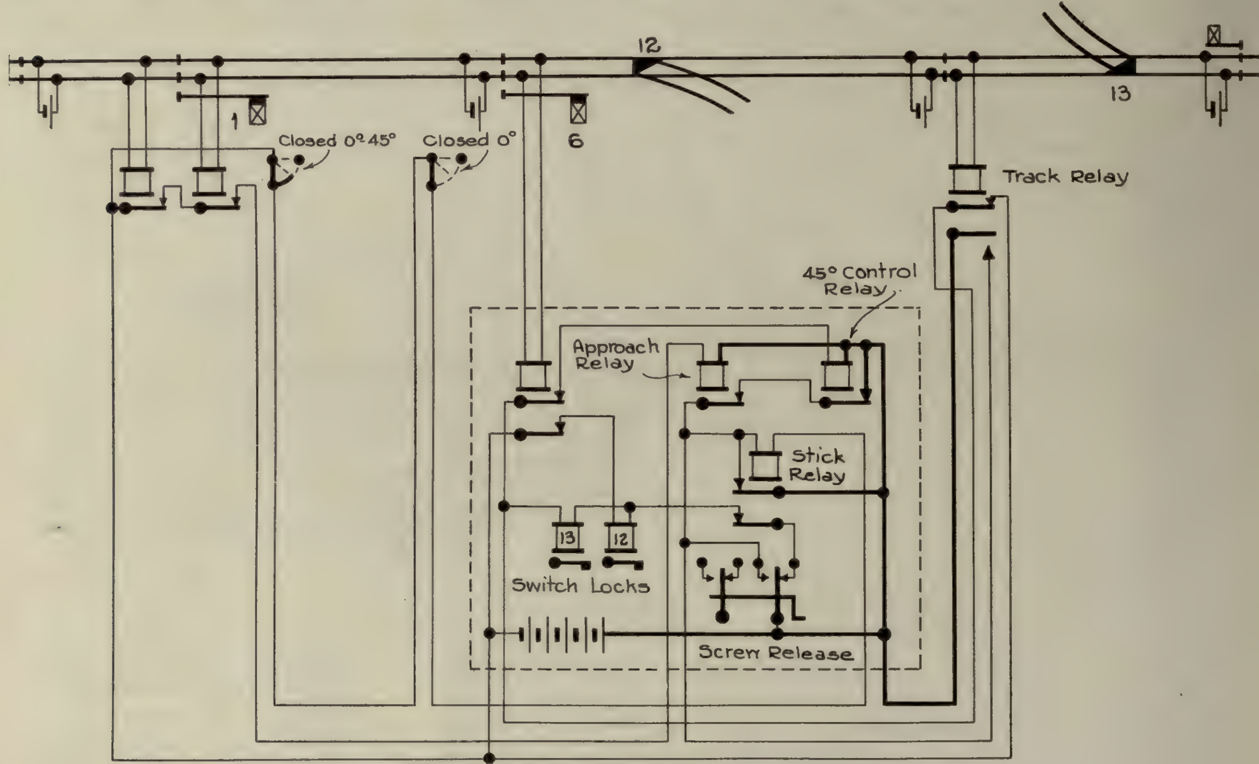


Fig. 2077. Typical Route Locking Circuit.

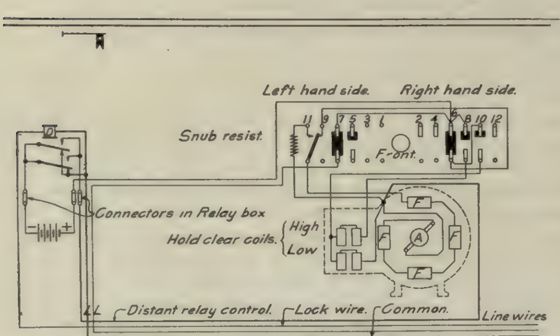


Fig. 2078. Circuit for Control of Power Distant Signal, Showing Motor Connections.

screw release F (see Figs. 2843-2845) must be first reversed. This opens the slot circuit and restores the signal to normal: it also opens the circuit for relay C. These circuits cannot again be restored until the release is put normal. Relay C controls the circuits for all the switches in the route so that when it is open no switches can be moved. When the screw release is reversed it breaks the circuit for indicator G. The signal lever may then be restored to the normal position. When indicator G is de-energized, either by the presence of a train on the track circuit or by the screw release, it breaks the circuit of relay C and the snubbing circuit just described, and its back point closes. This completes the indication circuit as follows: From motor through main common, indication com-

Fig. 2077 shows an approach locking circuit which is effective only after signal 6 has been cleared and a train has approached into the preliminary section. The levers for all switches within the interlocking are equipped with full normal and full reverse electric locks, these locks being controlled through their respective track sections and a front point of the stick relay, which relay once picked up will be held up through its own front point until deenergized by the clearing of signal 6. When the stick relay has been thus deenergized the route will be held locked until the train, having accepted and placed signal 6 at stop, has passed on to the last track section of the plant, thereby again picking up the stick relay. If no train comes, signal 6 may be restored normal and the stick relay will pick up as shown in the circuits through the approach and 45 deg. control relays in series. The stick relay takes battery not only through the circuit controller on signal 6, but also in series through a controller (closed 45 to 90 deg.) on signal 1, which gives the caution indication for signal 6; this feature prevents the operator from taking away the route in case signal 1 fails to return to the caution position after signal 6 has been placed normal. The stick relay may be picked up regardless of the relays which control it, by means of the hand screw release; the locks on the switch levers are broken through this hand screw release in its normal position, thus forcing the operator to screw the hand release back to its normal position before the route may be released.

Fig. 2074 shows an approach locking circuit, effective as soon as the home or the distant signal, as desired, assumes the proceed position; it also illustrates the mechanical action of the hand screw release (see Fig. 2856). The home signal lever is equipped with a half reverse lock which is controlled in series through the front points of the track and stick relays. This stick relay is held up through its own front point, being

de-energized at the time when the home or the distant signal is cleared, as the case may be; the stick relay will pick up again only when the signal, through which its circuit is broken, has gone to stop and the train has entered the home section. Therefore, reversing the lever which controls this signal, de-energizes the lock on the home signal lever, thus holding the route locked until the train has passed completely through the interlocking. In case it is desired to change the route before the arrival of the train, the operator may screw over the hand release which will energize the lock on the home lever irrespective of the stick and track relays. The screw release has a projection which in the reverse position butts against the locking

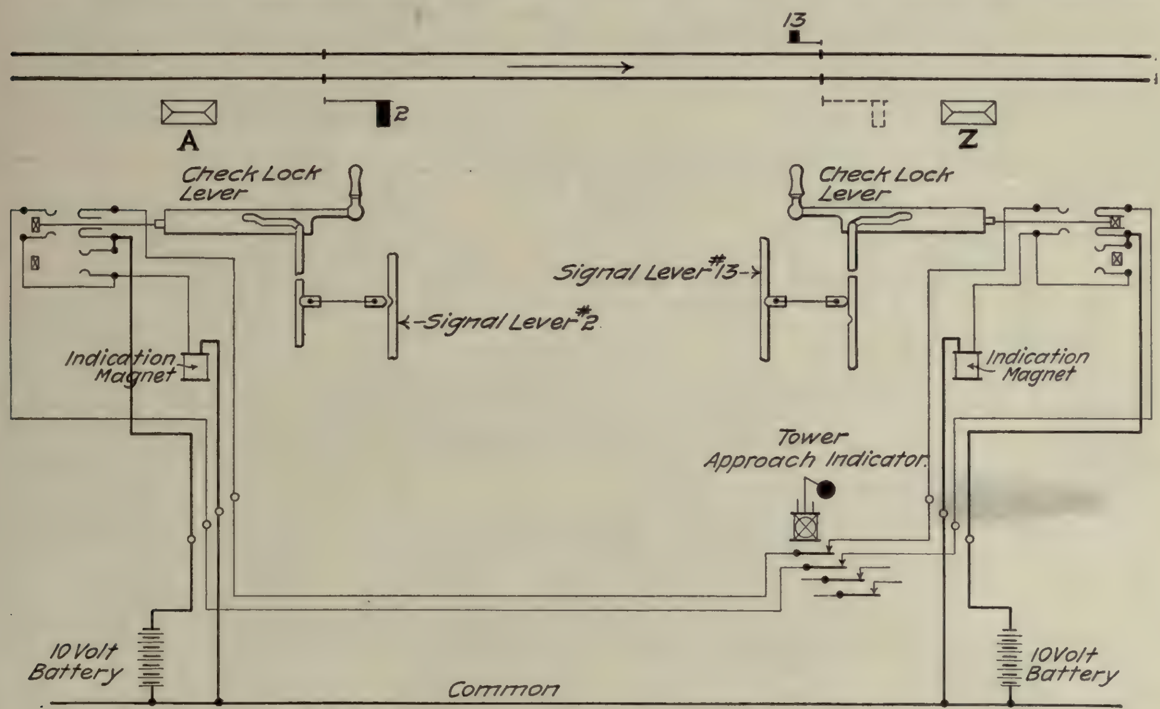


Fig. 2079. Check Locking Circuits for Electric Interlocking. General Railway Signal Company.

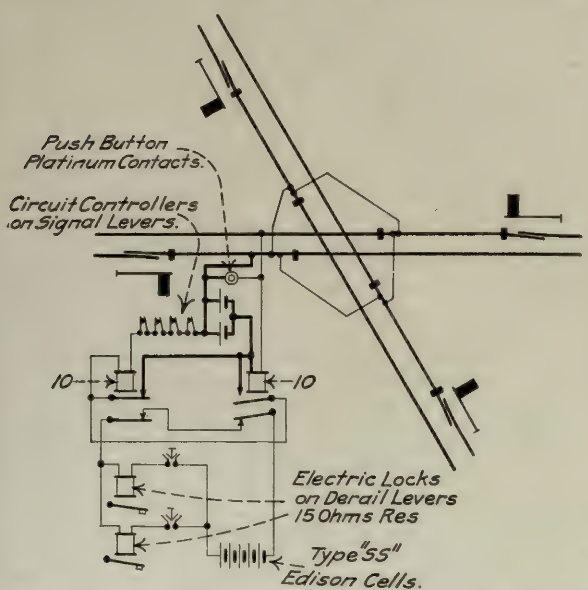


Fig. 2080. Electric Locking Circuits for Single Track Crossing. New York Central & Hudson River.

bar on which is mounted the driving dog of the home signal lever, thereby mechanically locking the tappets of all functions in the route in the positions assumed. This insures the restoration of the screw release to its normal position before the route can be changed.

Where two interlocking plants are situated close together and each has signals governing toward the other on the same track, it is necessary to provide means to prevent any two such opposing signals from being cleared at the same time. Such an arrangement of apparatus is called "check locking."

Fig. 2079 illustrates a method of accomplishing check locking at two electric interlocking plants. Each plant is provided with a check lock lever. A is the master plant, as its signal (2) governs in the normal direction of traffic, and under normal traffic conditions may be operated without interference from the check locking. The check lock levers are interlocked with the signal levers. The check lock lever at A, when reversed, locks lever 2 normal, and at Z, signal lever 13, when reversed, locks the check lock lever reversed.

To clear signal 13 for a reverse movement, the check lock lever at A is first reversed; this locks signal 2 normal. In reversing this lever the lower contact block bridges the two lower springs at the reverse indication stop, closing a local circuit through the indication magnet, and permitting a full reversal of the lever. The upper contact block also bridges the two upper reverse contact springs, which closes a circuit from the 10-volt battery at A, through the upper line wire, the upper contact of the approach indicator at Z (insuring that the track section between the two towers is unoccupied) to the upper reverse contact spring of the check lock lever at Z. This lever is now reversed as far as the indication stop. When this is reached, its upper contact block bridges the contact springs at that point, completing the circuit just traced, through the indication magnet to common and back to its battery at A. This energizes the indication magnet and permits the check lock lever at Z to complete its reverse stroke, releasing the mechanical locking which has, up to this time, held signal lever 13 in its normal position. In this last portion of the stroke it also breaks the contact just made, de-energizing the indication magnet.

Trains may now be forwarded from Z to A, their movement being governed by signal 13.

To restore the normal traffic (signal 13 having been put in the stop position), the check lock lever at Z is moved to its normal position, locking signal lever 13 normal. In going to this position the lower contact acts in the same manner as with the lever at A, when being reversed. In the normal position of the lever at Z its upper normal contact springs are bridged, closing a circuit from the 10-volt battery at Z, through the second contact on the approach indicator (again insuring that the track is clear between the two towers), the lower line wire, to the upper normal contact spring of the check lock lever at A. This lever is now moved against the normal indication stop, completing its indication circuit in the same manner as the lever at Z when reversed. Thus after both check lock levers are restored to their full normal position, signal lever 2 may be reversed, and traffic resumed in its normal direction.

Fig. 2081 shows check locking circuits in use between two interlocking plants situated at each end of the Bloomingburgh Tunnel, on the New York, Ontario & Western. This installation comes near being single track controlled manual blocking,

and, in fact, the same may be said of any effective form of check locking.

X and X′, electrically locked circuit controllers (see Figs. 357-357), are used instead of check lock levers. Indicators Y, Y′ control the slot circuits and are controlled by X and X′. The circuit for X and X′ is as follows: Wire B, magnet X′, wire 1, circuit controller on latch of lever 2, wire 1 *a*, track relay point, wire 1 *b*, track relay points at tower 5, wire 1 *d*, circuit controller on latch of lever 20, wire 1 *e*, circuit controller on latch of lever 18, wire 1 *f*, magnet X, to wire O. Wires B and O are the two main battery feeds. It will be noted that reversal of the knife switch reverses polarity of feeds, thereby counteracting any tendency toward residual magnetism in the instruments.

To send a train from tower 5 to tower 6 no manipulation of X or X′ is necessary. Signalman at 6 reverses lever 5, thereby closing circuit controller on its tappet. Current now flows from B at tower 6, through circuit controller on lever 5, wire 2, controller X′, wire 2 *a*, point of track relay, wire 2 *b*, track relay points at tower 5, wire 2 *d*, controller X, wire 2 *e*, magnet of Y, to O. This energizes Y and closes the slot circuit for signal 18 or 20 (according to the position of 14), when latch of either is raised. Either signal can now be cleared for a train, but such action opens the circuit for X and X′ and locks them in their normal position. Lever 12 must be reversed before 18 or 20. This shunts out the circuits for X, X′ and Y from the points of eastbound track relay. This permits a train to stand on the eastbound circuit beyond the fouling point of the crossover, while another is making a normal westbound movement. The circuit controller on lever 14 selects slot circuits for signals 18 and 20.

To move a train from tower 6 to tower 5, controllers X and X′ and lever 1 (at tower 5) must be reversed; also switch and derail 4 at tower 6 must be reversed. This closes a circuit from B at tower 5, through controller on latch of lever 1, wire 3, lower contact of X (now closed), wire 2 *d*, points of track relays, wire 2 *b*, circuit controller of lever 4 (now closed), wire 2 *b*, circuit controller on lever 4 (now closed), wire 2 *a*, upper contact of X′ (now closed), wire 3 *a*, magnet of Y′, to O. This energizes Y′ and closes slot circuit for signals 1 and 2 when their lever latches are raised. Raising the latch of 2 breaks the circuit of X and X′, locking them reversed.

The presence of a train on the tunnel track circuit opens both control circuits, de-energizing the controllers X and X′ and indicators Y and Y′, which in turn opens their respective slot circuits automatically, putting the signals in the stop position, holding them there until the track circuit is clear, and also locking controllers X and X′ in whichever position they were last left. When crossover 12 is normal the track circuit on the eastbound track at tower 5 has the same effect, and when switch 4 is normal the same is true of the westbound track circuit at tower 6.

After the passage of a train in either direction it is not necessary to manipulate X and X′ for a following movement, but they must be changed for a movement in the opposite direction. Reversal of either X or X′ alone has no effect on Y or Y′, as they are then thrown into a closed circuit without battery.

Fig. 2082 illustrates a check lock circuit for installation where there is no preference as to direction of traffic. The check lock levers in towers A and Z are each equipped with a half reverse lever lock, these levers being so interlocked with the levers for the signals governing into the track between the towers that it is necessary for the check lock lever to be in the full reverse position before the signal lever mechanically interlocked therewith may be reversed. The operator in tower A, for instance, may reverse his check lock lever as far as the reverse indication point, the lever being held thus until the half reverse lock with which it is equipped is energized, this being accomplished as follows: Current will flow from the low voltage battery at tower Z, through full normal contacts on the check lock lever in that tower, the front point of track relay X (insuring that the track section between the two towers is unoccupied), the reverse contacts on check lock lever in tower A, through the lock in question and thence to common. The check lock being placed in the full reverse position releases the lever for signal 1, which may then be cleared for a movement from tower A to Z. The check lock lever in tower Z cannot be placed full reverse, thus allowing signal 2 to be cleared, until the lever for signal 1 and the check lock lever in tower A have first been restored to the full normal position. The operations for securing the release of lever 2 are the same as those already described in connection with signal lever 1.

Fig. 2083 illustrates a typical circuit for the control of signals installed for tunnel protection. Signal 1 normally stands at the stop position, being cleared through a preliminary clearing section, while signal 2 under normal conditions assumes the clear position. The control relay for signal 1 is broken through the track relay of the tunnel section and through the circuit breaker on signal 2 closed only at 0 deg. The control relay for signal 2 is likewise governed through the track section between signals 1 and 2 and a circuit breaker on the opposing signal closed only at 0 deg.; it is also controlled in series through the track relay of the clearing section. Since the signals are interlocked against each other, it is impossible for both signals to be cleared at the same time, even through the improper operation of one of the signals. A train running from left to right, on entering the clearing section, will put signal 2 to stop; if no train is between signals 1 and 2, the control relay for signal 1 will immediately pick up and signal 1 go to the clear position. Signal

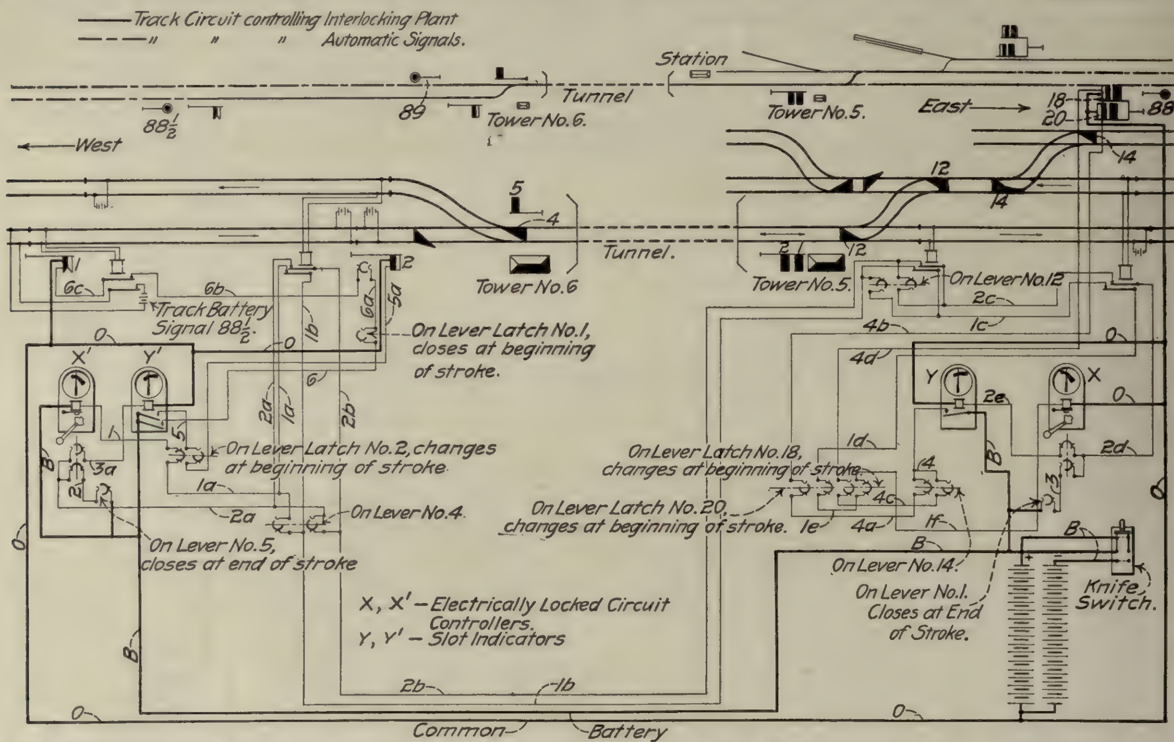


Fig. 2081. Check Locking Circuits and Track Diagram, Bloomingburgh Tunnel. New York, Ontario & Western.

1 will automatically go to stop when passed by the train, and until such time as the train will be clear of the tunnel section neither signal 1 nor 2 can give a proceed indication. A movement may then be made from the right, providing another train has not in the meantime entered the approach section for signal 1.

restore his home signal lever to the normal position while the train is in the home section. Fig. 2086 shows a route locking circuit, Fig. 2087 a track indicating circuit and Fig. 2088 an approach locking circuit.

Facing point locks are called for on these five plans. These would be placed at mechanical plants. If the circuits are used

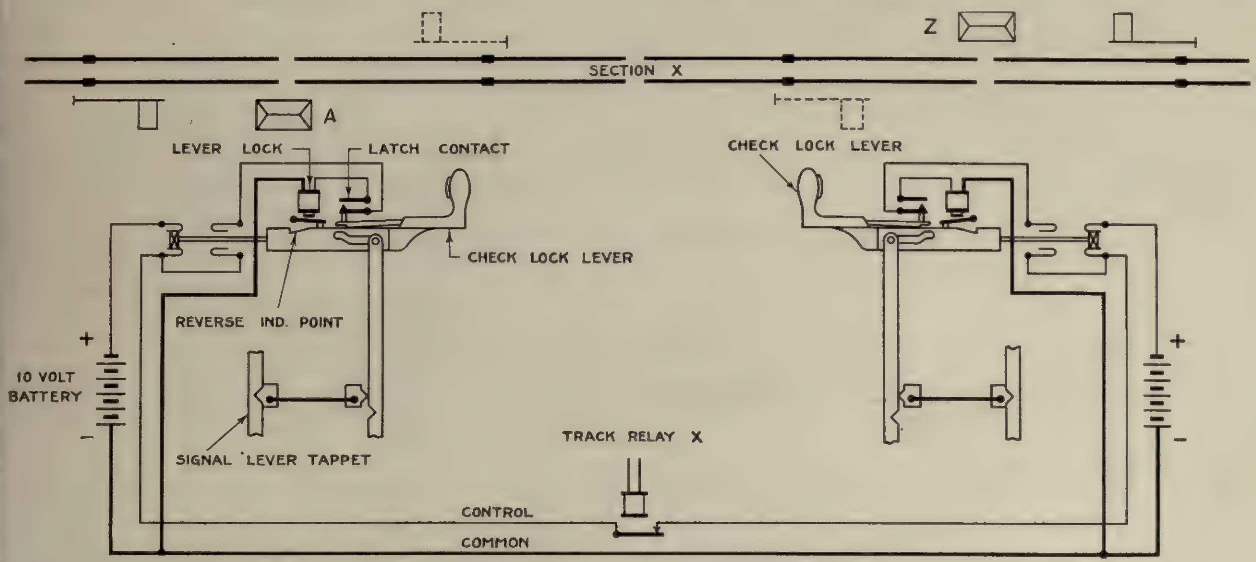


Fig. 2082. Check Lock Circuit. General Railway Signal Company.

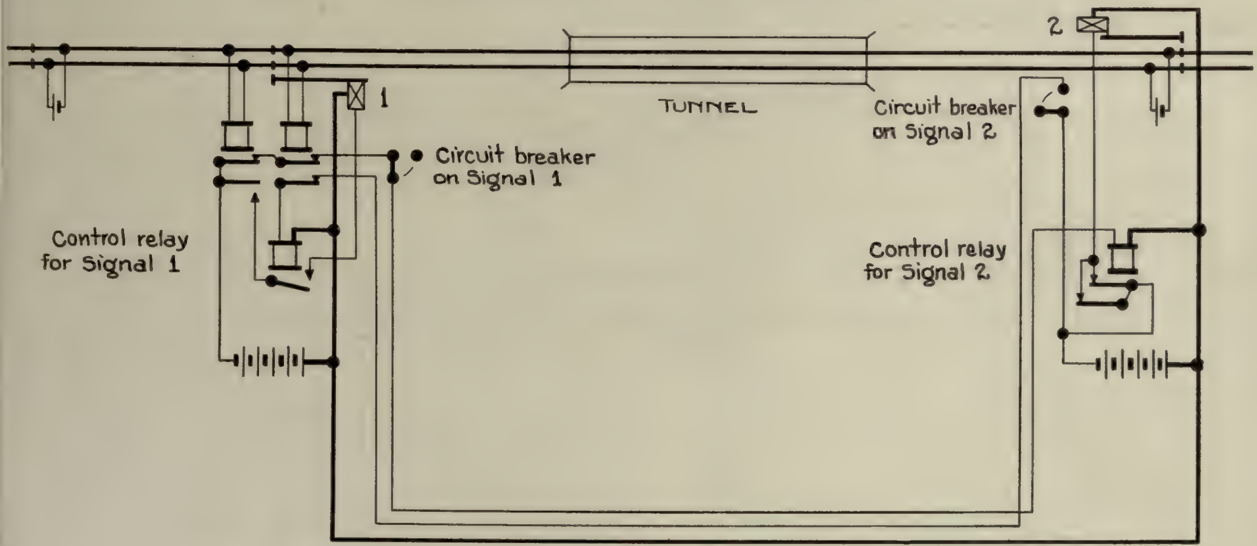


Fig. 2083. Circuit for Tunnel Protection. General Railway Signal Company.

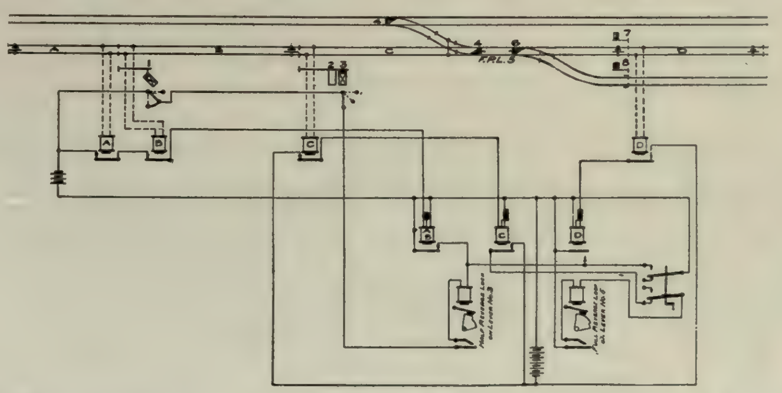


Fig. 2084. Approach and Route Locking for Slotted or Semi-Automatic Stick Signals. Railway Signal Association.

Figs. 2084-2088 show electric locking circuits for both mechanical and power interlocking plants, presented at the 1911 convention of the Railway Signal Association. Figs. 2084-2085 show complete electric locking, the former being recommended for plants where signals have semi-automatic control; and the latter for plants not having such control, and for other places where it is thought desirable to compel the operator to

at power plants lever No. 5 can be a key or route lever so arranged as to lock all switches in the route; or separate locks can be placed on each switch lever, or some switch or derail lever can be chosen to perform the functions of the key lever. At electric interlocking plants the locks might be done away with and relays substituted, which would open suitable control or indication circuits.

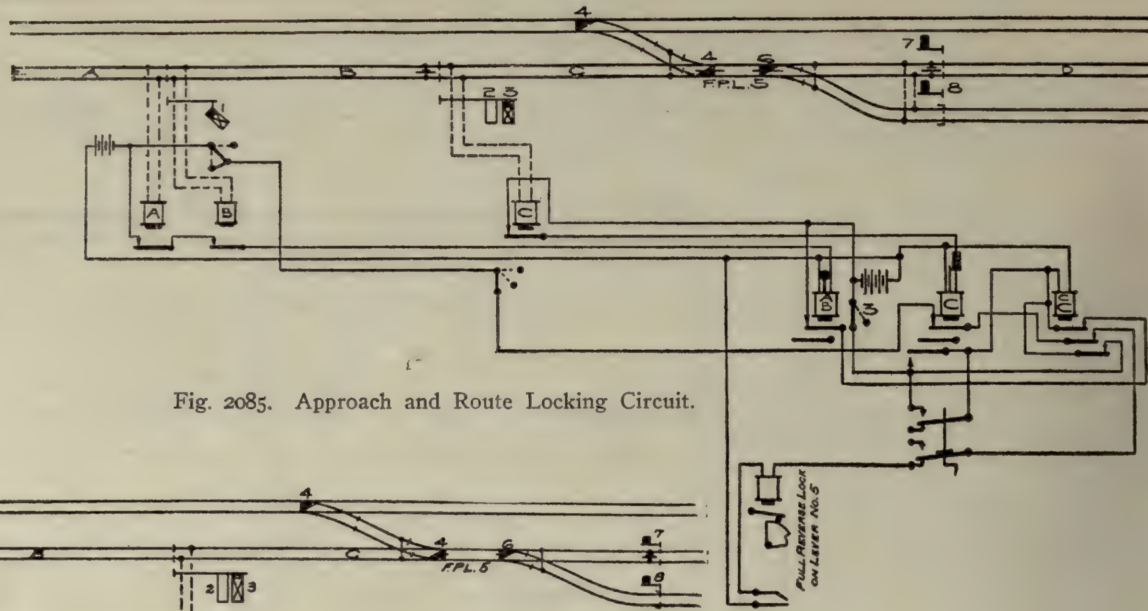


Fig. 2085. Approach and Route Locking Circuit.

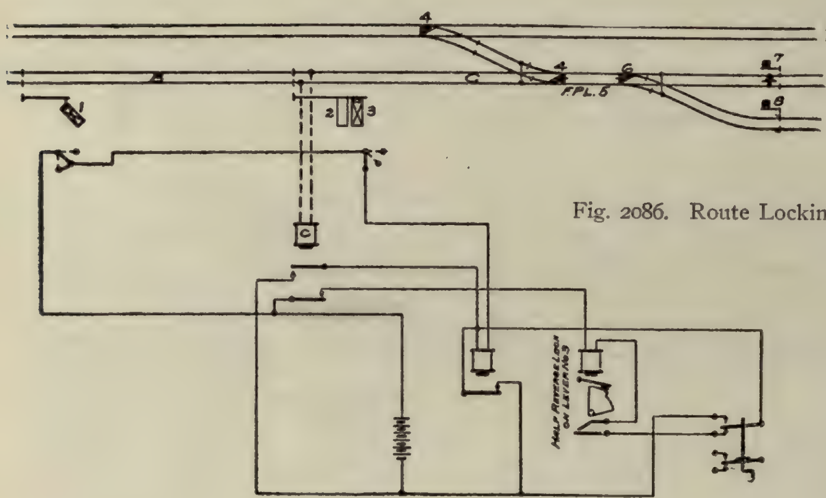


Fig. 2086. Route Locking Circuit.

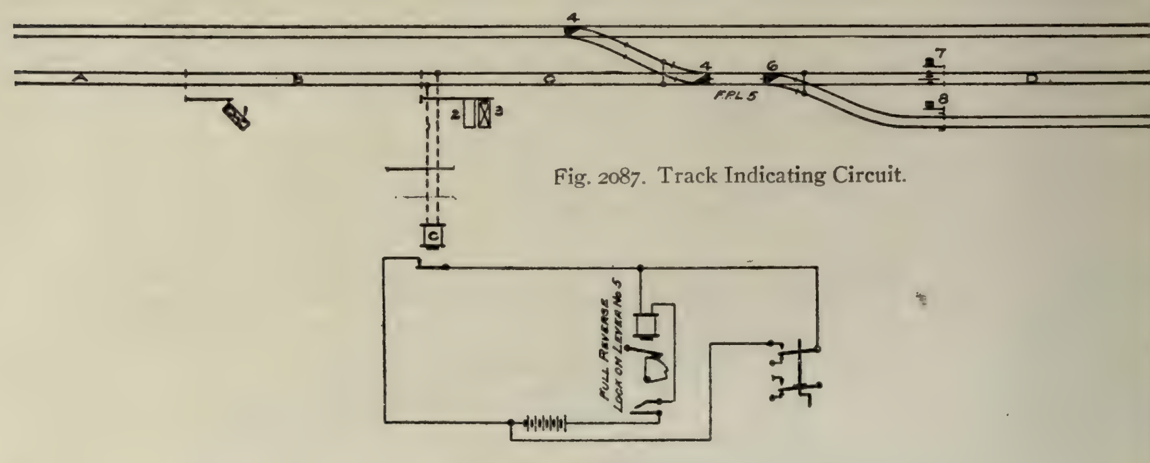


Fig. 2087. Track Indicating Circuit.

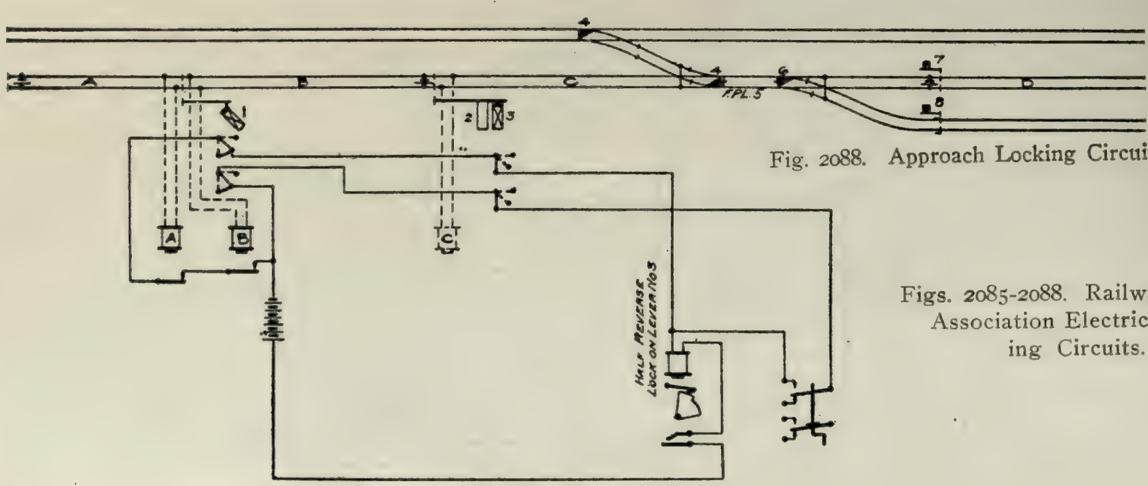


Fig. 2088. Approach Locking Circuit.

Figs. 2085-2088. Railway Signal Association Electric Locking Circuits.

HIGHWAY CROSSING SIGNALS

Pages 298-324 Figures 2089-2242

CROSSING BELL APPLICATIONS.

The ordinary bell installation for a double track grade crossing at a street or highway is shown by Fig. 2089. A bonded section of track, 1,500 ft. to one-half mile or more, is used on each track in the direction from which trains approach. Insulations are used at the end of these sections as shown at A, B and C. An interlocking relay (with the locking pawl removed) is used to control the local bell circuit. Two ordinary relays would answer as well, but it is sometimes desirable to maintain the interlocking type as a standard for bell work, and it requires somewhat less space. A train entering the ringing sections at A or C will short circuit the coils D or E, respectively, and drop an armature. These armatures carry contact springs that close a local bell circuit on a back contact so that the bell G will ring as long as the circuit of battery F is closed, that is, until the armatures of both D and E are "picked up," which occurs when the train passes out of the sections A to B or C to B. The notations on the cut are self-explanatory.

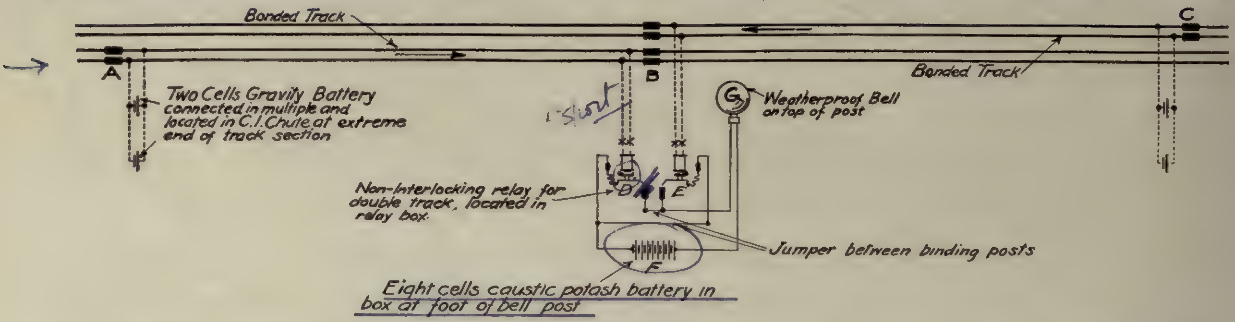


Fig. 2089. Arrangement for Double Track Highway Crossing Bell. The Union Switch & Signal Company.

apparatus required will be a relay at the crossing and two keys located so that they will be convenient to trainmen or operators. The momentary closing of either key contact cuts the bell out or in, it not being necessary to retain the finger on the key for more than an instant. In connection with this feature it should be understood that only when a train is on the track section approaching the crossing can the bell be manually cut out. It may again be cut in, when it will ring until the train passes over the highway; or should the operator neglect to cut the bell in, the train will automatically perform this operation in passing out of the bonded sections, and restore the instruments to their normal positions so that the bell will again ring for the next approaching train. The following examples will illustrate a few of the conditions met in actual practice and will give an idea of the many instances where a highway crossing bell can be used successfully and to advantage at points where the track layout or switching conditions are somewhat complicated:

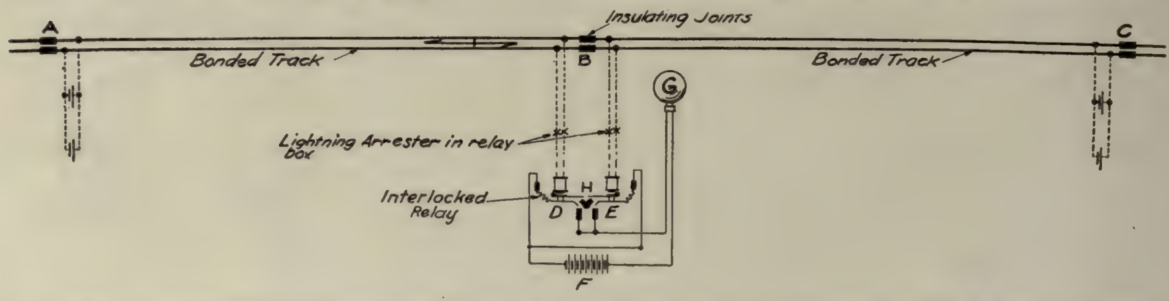


Fig. 2090. Arrangement for Single Track Highway Crossing Bell. The Union Switch & Signal Company.

A single track crossing bell layout is shown in Fig. 2090. As stated in the description of Fig. 2089, the track is bonded for 1,500 ft. to one-half mile or more on each side of the crossing from A to B and C to B. As a train enters from either end, the interlocking relay makes back contact on one or the other of the contact fingers attached to the armatures D and E, which completes the local bell circuit of battery F. As it is desired to stop the bell as soon as a train has passed over the crossing, after entering the ringing section, a means must be provided to prevent the armature of that part of the relay controlled from the section beyond the crossing from dropping far enough to make back contact when a train passes the crossing. The locking pawl H is provided for this purpose, as is explained in connection with Figs. 2119-2123. Thus, the bell will ring from the time a train enters the section until it passes over the crossing.

Fig. 2091 will serve to illustrate a number of special conditions under which it is advisable to use special keys in addition to the standard layout, in order to stop and start a crossing bell in connection with certain train movements as a means of preventing false alarms and continuous ringing. The additional

Case 1. If an approaching train enters the bonded section at A and stops at Station F the bell E at the highway would ordinarily ring during the time that stop is made and until the train again proceeds and passes beyond the crossing. In consequence, the bell is ringing during the time that train is at a stop, and the street is open to the safe passage of the public. If such a condition is allowed to continue, the bell ceases to become a warning and is locally classed as a public nuisance. A stop and start key is installed in the station. Under these conditions the agent presses the stop key when the train slows down and the bell consequently ceases to ring. If the crossing is very close to the station no starting key is required, for the train may proceed slowly over the crossing with the engine bell ringing, and in passing beyond the bonded sections will automatically restore the instruments, as before stated. Should the crossing be some distance from the station, however, the agent may press a starting key when the train is ready to proceed, and give the proper warning at the highway. In this latter instance of course the bell will stop ringing when the entire train has passed over the crossing.

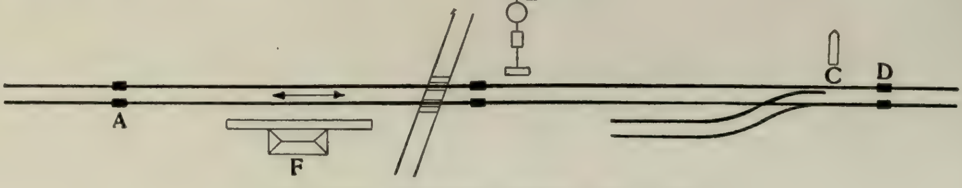


Fig. 2091. Special Crossing Bell Layout

Case 2. Referring to the same layout, should F be a day

station only, or for any reason should it be undesirable for the agent to handle operating keys, the same results may be obtained as outlined in Case 1, by inserting short one-rail sections in the track circuit approaching the crossing in lieu of the keys, and thereby make the cut-in and cut-out feature dependent entirely on the location of the engine relative to the crossing; or a train in coming to a stop at the station passes onto a stop section and automatically cuts the bell out of circuit. When the same train again proceeds the engine enters a starting section located at a specified distance from the crossing and bell again rings, it being understood that the stop and start sections are such a short distance apart that a through train approaching the crossing at speed will give practically a continuous warn-

D will give a false alarm at the crossing during the time that section CD is occupied. This situation can be properly protected so that bell will not ring for a train entering CD from the siding, provided the train proceeds in a direction away from the crossing. Should, however, a train clear the switch and run toward the highway a sufficient warning will be given.

Figs. 2095-2096 illustrate circuits used to cover some of the conditions mentioned above.

Fig. 2092 shows the circuits for a double track crossing bell, using the relay shown in Fig. 2128, but with fingers so arranged as not to interlock. A train in either section shunts the relay magnet, allowing its finger to make contact with back point, thereby establishing a circuit through the bell.

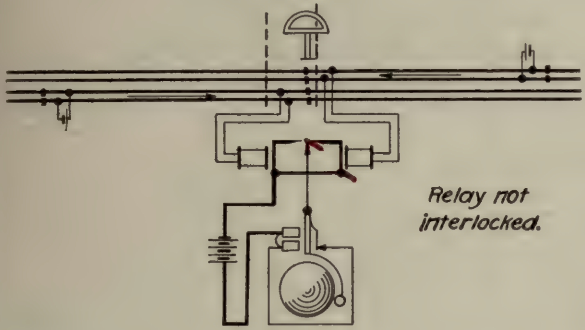


Fig. 2092. Crossing Bell Circuits, Double Track. Railroad Supply Company.

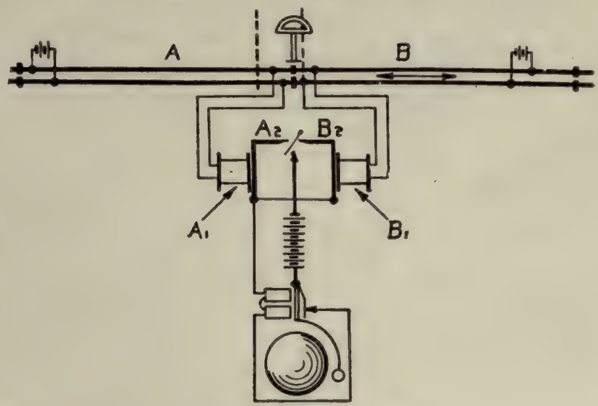


Fig. 2093. Crossing Bell Circuits, Single Track. Railroad Supply Company.

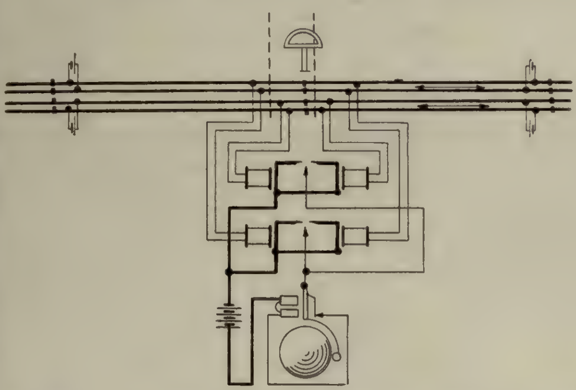


Fig. 2094. Crossing Bell Circuits, Two Single Tracks. Railroad Supply Company.

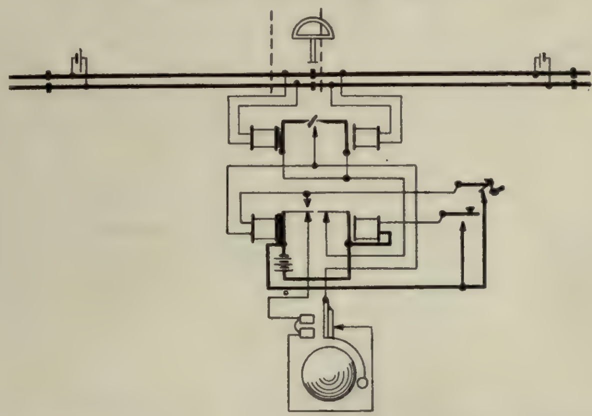


Fig. 2095. Crossing Bell Circuits, Single Track, with "Cut-out" and "Cut-in" Keys. Railroad Supply Company.

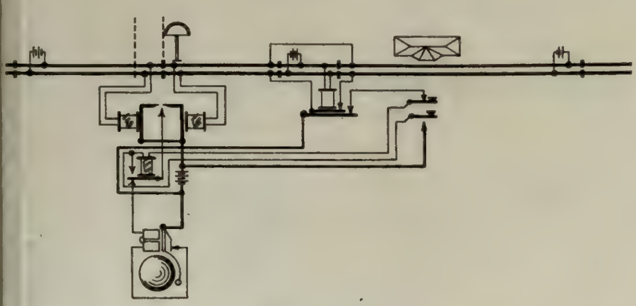


Fig. 2096. Crossing Bell Circuits, Single Track, Automatic Starting Section, with "Cut-out" and "Cut-in" Keys. Railroad Supply Company.

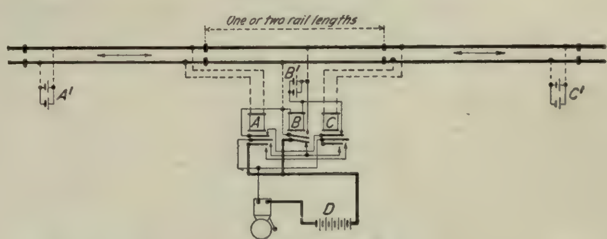


Fig. 2097. Single Track Crossing Bell Circuits, Without Interlocking Relay. Delaware, Lackawanna & Western.

ing, as its effect in passing over the cut-out and cut-in section will cause no noticeable interruption to the bell circuit.

Case 3. Should the approach section to a bell include a switch as shown at C (Fig. 2091), it is advisable to provide a stop and a start key at such a switching point for the convenience of train men in controlling the ringing of the bell while switch is being used and cars are being switched on and off the bonded section. The keys are usually placed in a shelter and mounted upon a post adjacent to the switchstand. Keys at C and F, or at a number of different points, may be used to control the same bell without in any way conflicting with its operation.

Case 4. Should C (Fig. 2091) be a switch leading to a passing siding or at the end of a double track, it may be readily seen that a train coming on to main line at C and proceeding toward

Fig. 2093 shows the circuits for a single track crossing bell, using the relay shown in Fig. 2128. A train in either section affects the relay as in Fig. 2092, but when it passes from one section to the other, the magnet of the first section picks up, raising both metal strips and thereby stopping bell.

Fig. 2094 shows two single track installations operating one bell in common. The circuit arrangement is an adaptation of Fig. 2093.

Fig. 2095 shows a device for stopping the bell while a train is in the initial section and for starting it again if so desired. The relays are similar to the one shown in Fig. 2128. A train in either section de-energizes one or the other of the magnets of upper relay completing a circuit from the top cell of battery through the back point of the left-hand side of the lower relay. A, or B,

bell, back point of upper relay, finger, back right-hand point and finger of lower relay, back to battery. The lower relay is normally de-energized and is not interlocked. If desired to stop the bell, the upper key is pressed down. This completes a circuit from battery, through key, left-hand magnet of lower relay, back point and finger of upper relay, back point and finger of right-hand magnet of lower relay to battery. This energizes the left-hand magnet of the lower relay which picks up its armature and breaks the bell circuit. At the same time it establishes a "stick" circuit through its front point, thereby keeping itself energized while the train remains in the section. To start bell again, the lower key is pressed which energizes right-hand section proper, thereby assuring continuous ringing under normal operation. This arrangement is used where trains make a station stop on a crossing bell track circuit.

Fig. 2097 shows how a single track crossing bell may be operated without an interlocking relay. Suppose a train enters the section at battery A′. Relay A will be de-energized and cause the bell to ring through a circuit from battery D, through bell, middle back contact of relay A, back contact of relay B, to battery. When the train enters the short middle section, relay B picks up and opens the bell circuit. Relay A also picks up when train has left its section. Relay B is a "stick" relay and, when energized, closes its own circuit from battery B′ through

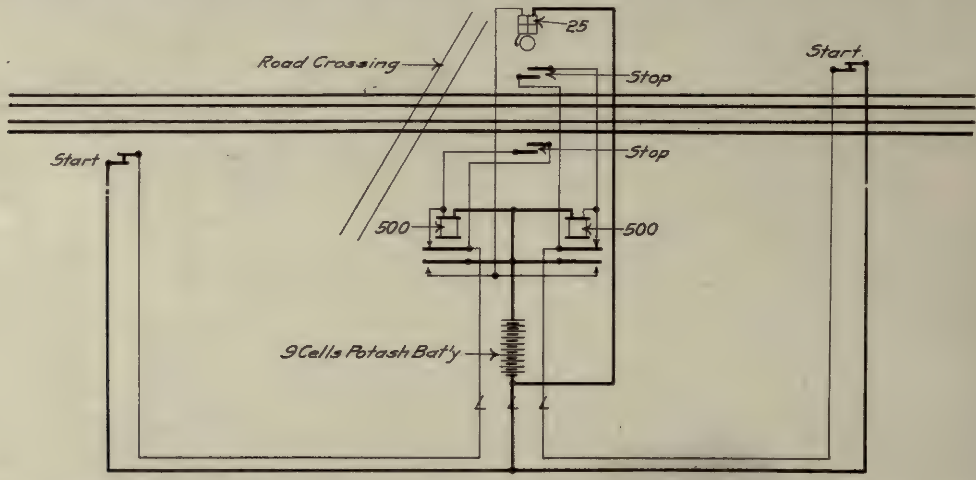


Fig. 2098. Normally Closed Line Circuits for Double Track Crossing Bell, with Track Instruments.

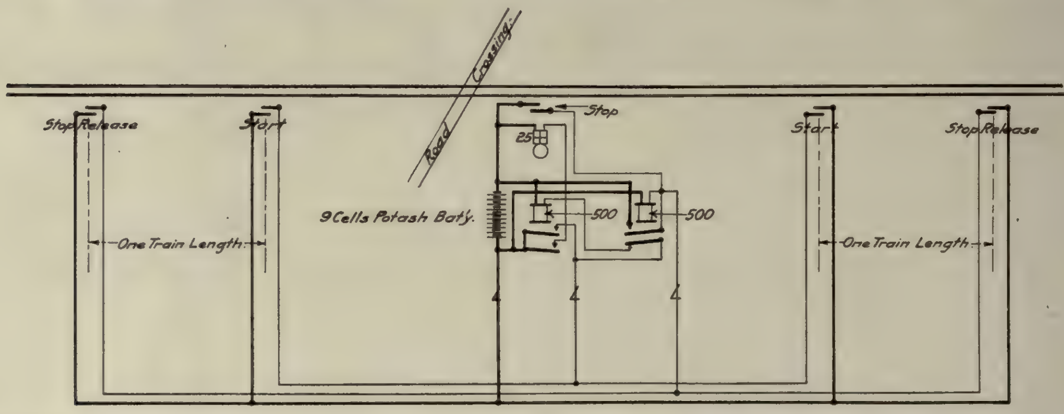


Fig. 2099. Normally Open Line Circuits for Single Track Crossing Bell, with Track Instruments.

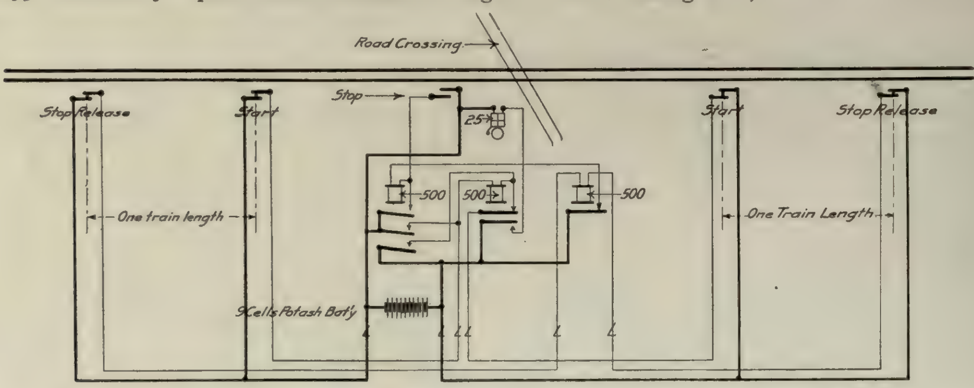


Fig. 2100. Normally Closed Line Circuits for Single Track Crossing Bell, with Track Instruments.

magnet of the lower relay opening the "stick" circuit and de-energizing the left-hand coil. Releasing the lower key restores the lower relay to its normal condition, and the bell rings until the train has passed out of the section, as in Fig. 2093. The "stick" circuit is broken in any event when the train leaves the section. This arrangement is used where much switching is to be done on the track circuit.

Fig. 2096 shows a circuit to accomplish the same results as Fig. 2095, except that the bell starts automatically when train reaches the short independent track circuit. The "stick" relay is energized by pressing the lower key, and de-energized by pressing the upper key, or by the opening of the track relay in the short section. This relay also breaks the circuit for the bell track front point and coil of relay B, back to battery B′, when either A or C is de-energized. When the train enters the section C, the bell does not ring as its circuit remains broken by relay B. When the train passes battery C′, relay C picks up and shunts relay B by a short circuit from battery B′, through front point of relay B, front points of relays A and C to battery B′. This de-energizes relay B and restores the apparatus to its normal condition. Suppose while the first train was in track circuit C a second train should enter track circuit A. Relays A and C would both be de-energized and relay B energized. The bell would ring for the second train by a circuit from battery D, through the lower bell, lower back contact of relay C, lower back contact of relay A, back to battery D.

Fig. 2098 shows double track crossing bell circuits using track instruments or "trips." A train passing over either instrument marked "start" will open the circuit of the 500-ohm relay with which it is connected, de-energizing the relay and closing the bell circuit. The relay breaks its own circuit and the bell continues to ring until instrument marked "stop" is depressed, when the relay is again energized and completes the original "stick" circuit through its own armature and the starting instrument.

ergizes the right-hand relay which breaks the circuit for the first relay, stopping the bell, and closes its own circuit through a front point. Now depressing either starting instrument has no effect, but depressing either "stop release" instrument shunts the right-hand relay and restores the apparatus to normal.

Fig. 2100 shows single track crossing bell circuits using track instruments, with control relays normally energized. Depression of either starting instrument breaks "stick" circuit of mid-

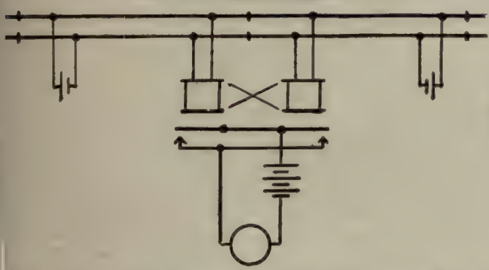


Fig. 2101. Bell Starts as Train Approaches and Stops as the Last Car Passes.

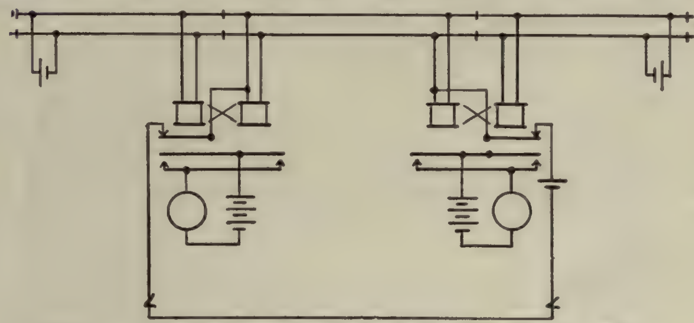


Fig. 2102. Both Bells Start Ringing at the Same Time and Each Stops as the Last Car Passes.

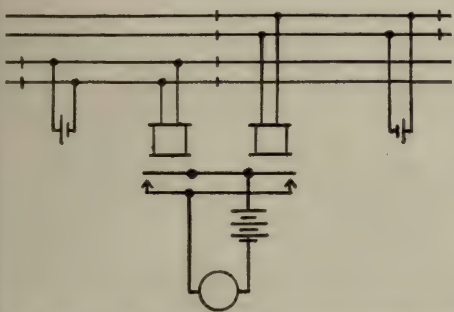


Fig. 2103. Bell Starts as Trains Approach on Either Track and Stops as the Last Car Passes.

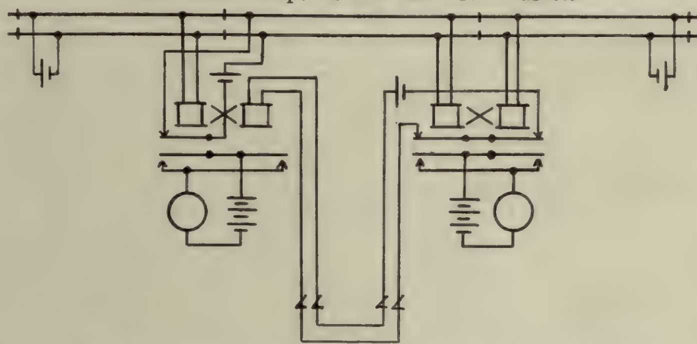


Fig. 2104. Both Bells Start Ringing at the Same Time and Each Stops as the Last Car Passes.

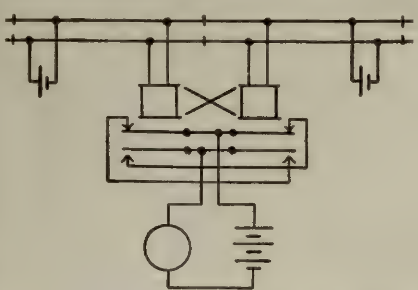


Fig. 2105. Bell Starts as Train Approaches and Stops as the Engine Passes.

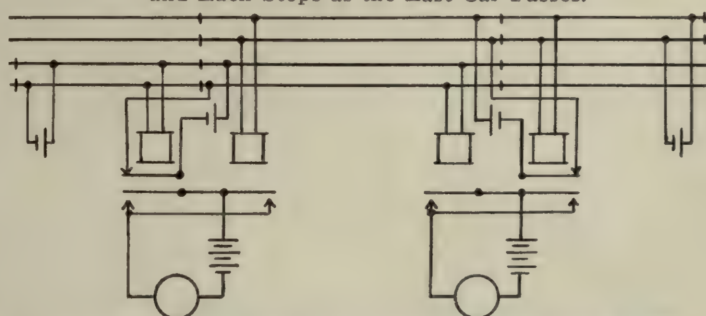


Fig. 2106. Bells Start at the Same Time and Each Stops at the Last Car. Interlocking Features of Both Relays Removed.

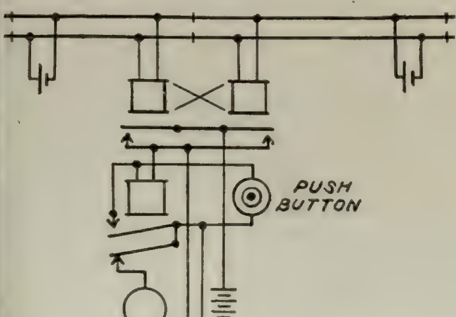


Fig. 2107. Bell Starts as Train Approaches and is Stopped by Push Button. Last Car Restores the Circuit to Normal.

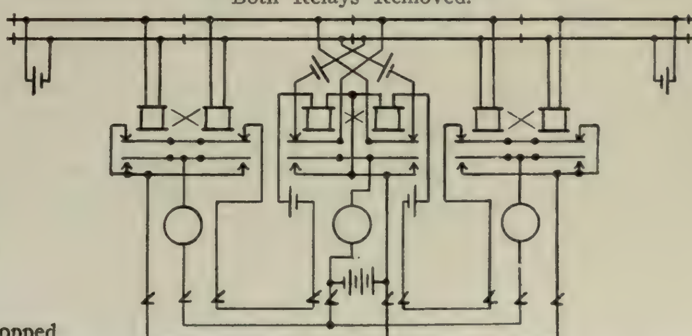


Fig. 2108. All Bells Start at the Same Time and Each Stops as the Last Car Passes.

Figs. 2101-2108. Diagrams of Crossing Bell Circuits. Bryant Zinc Company.

Fig. 2099 shows single track crossing bell circuits using track instruments with relays normally de-energized. The depression of a starting instrument energizes left-hand relay, which closes its own circuit through one front point and the bell circuit through the other. The "stick" circuit holds until the train reaches the crossing. Depressing the stopping instrument en-

dle relay, which rings the bell through its back contact. Depressing the "stop" instrument picks up the left-hand relay. This relay "sticks" through one front point and closes the circuit for middle relay through the other two. Depressing either "stop release" breaks the circuit of right-hand relay, which opens the circuit of left-hand relay, restoring the apparatus to normal.

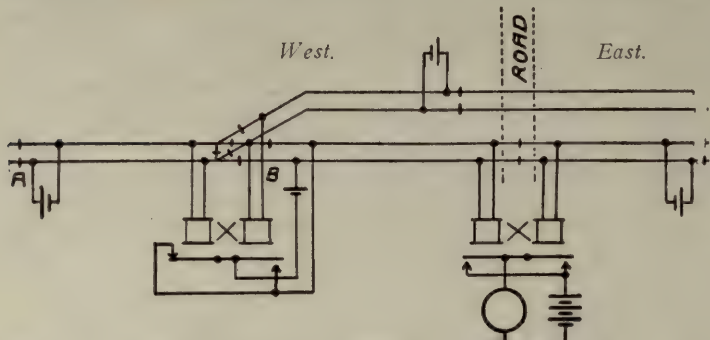


Fig. 2109. (Train Moving from Siding to Main Track Continuing West Will Not Cause Bell to Ring. If Train Goes East After Reaching Main Track, Bell Will Start to Ring When First Trucks Pass B. Through Eastbound Trains Start Bell at A. Bell Stops Ringing as it is Passed by the Last Car). Bryant Zinc Company.

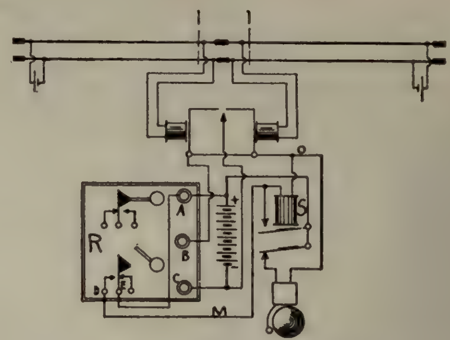


Fig. 2110. Single Track Circuit with Automatic Time Control Cut-out. Bell Rings for Predetermined Time if Train Stops Within Limits.

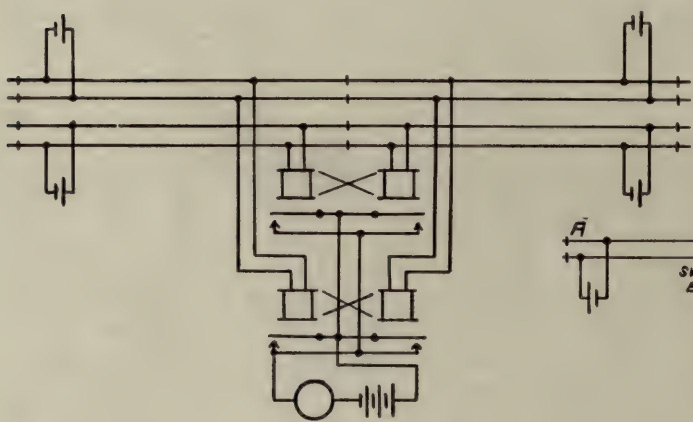


Fig. 2111. Bell Starts Ringing as Trains Approach Crossing on Either Track and Stops Ringing as it is Passed by the Last Car. Bryant Zinc Company.

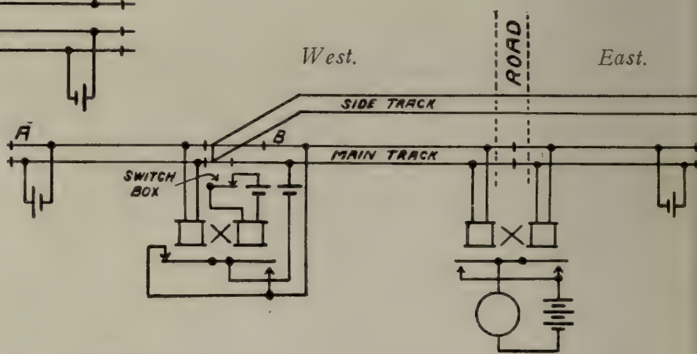
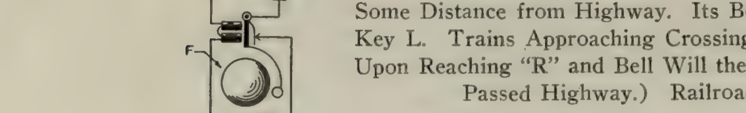
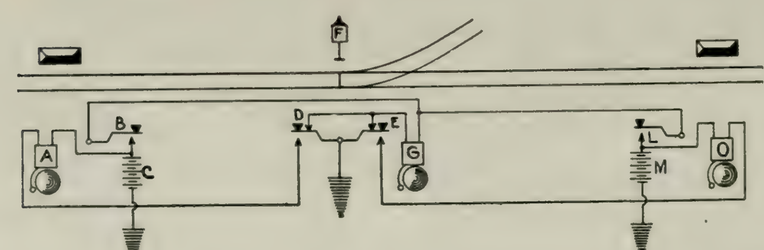


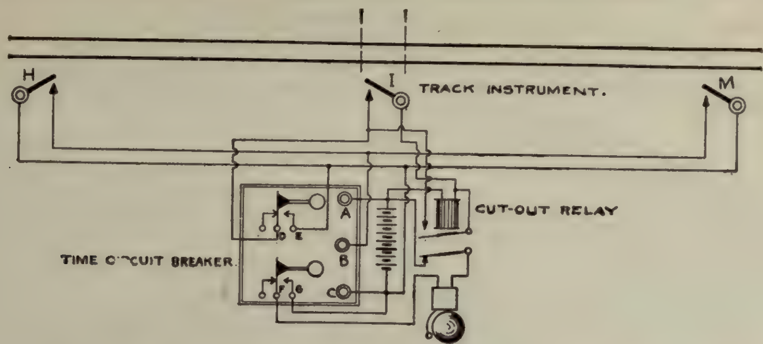
Fig. 2112. False Alarm Circuit for One Bell on Single Track Using Switch Box Operated by Siding Switch. (See Fig. 2109.) Bryant Zinc Company.



Figs. 2113-2114. Standard Single Track Circuit, with Entirely Automatic Cut-in Section. (Used at Places Where Trains Stand on Tracks Some Distance from Highway. Its Bell Has Been Silenced by Strap Key L. Trains Approaching Crossing Will Automatically Start Bell Upon Reaching "R" and Bell Will then Ring until Rear Trucks Have Passed Highway.) Railroad Supply Company.



Figs. 2115-2116. Standard Circuit for Bell System at Outlying Districts.



Figs. 2117-2118. Standard Circuit for Single Track Without Track Circuits. Bell Begins to Ring at Outlying Track Instruments and Is Silenced When Train Reaches Highway. Railroad Supply Company.

INTERLOCKING RELAYS

UNION INTERLOCKING RELAY.

Figs. 2119-2123 illustrate the method of interlocking employed in the Union Switch & Signal Co.'s relays. To apply this to the enclosed relay shown in Fig. 2143 it is necessary to consider the pawl inverted and the armatures hinged on the opposite sides at the pole pieces.

Fig. 2119 illustrates the normal condition of the relay with both coils energized and both armatures picked up. In this position of the relay the swinging pawl F is held as shown by the weight at its lower end.

In Fig. 2120 a train has entered the section at A and the arm H has dropped on account of the de-energizing of relay magnet K. When the arm H dropped it tilted the pawl F slightly to the left and at the same time the contact finger E closed the circuit through the back contact M causing the bell to ring.

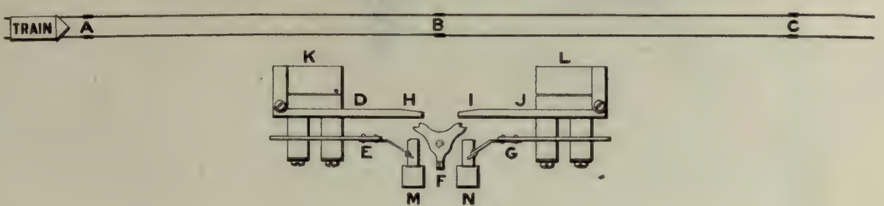


Fig. 2119.

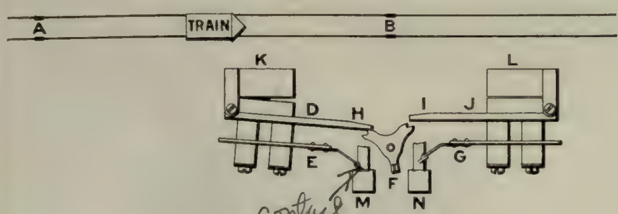


Fig. 2120

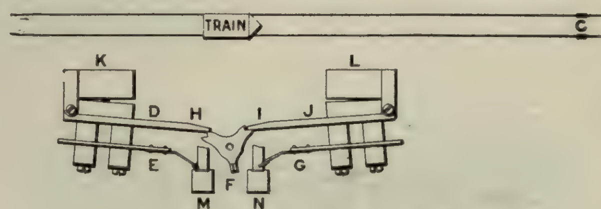


Fig. 2121.

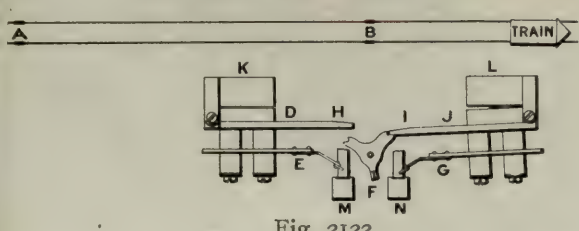


Fig. 2122.

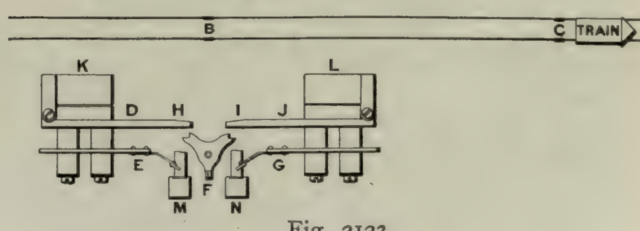


Fig. 2123.

Figs. 2119-2123. Showing Operation of Locking Pawl in Interlocking Relay.

Fig. 2121 shows the condition of the apparatus when the train is spanning the insulation between the two sections and is short-circuiting the relays in both. In the figure both magnets are de-energized, but on account of the position of the pawl F the arm I drops into the notch of the pawl. Its movement to this position is not enough to carry the contact finger G to the back contact N, so that G is thus prevented from closing the bell-ringing circuit at N.

Fig. 2122 shows the apparatus after the train has passed the dividing line between the two sections and is in the second track circuit section. Magnet K has picked up its armature and the contact finger E no longer closes the bell circuit through M, so that the bell is not ringing. But magnet L is still de-energized on account of the presence of the train to the right of the insulated joints B, and the arm I is held by the notch in the pawl F so that the contact finger G still does not close the bell circuit at N. Thus whichever armature drops first causes the bell to ring while the train is in the corresponding side of the track circuit but at the same time prevents the other armature from closing the bell circuit even though the magnet governing this other armature is de-energized.

INTERLOCKING RELAYS.

Fig. 2124 shows an interlocking relay consisting of two track relays mounted on the same base. Each armature carries a projection to which is fastened a lug carrying a roller. Two pawls, G and H, are suspended between the projections. These pawls are pivoted and so counterweighted as to stand normally with their straight sides vertical. In the figure the left-hand armature, B, is shown released. In this position its roller bears against pawl G, forcing its upper extremity under projection on armature E. If the magnet D should be de-energized, E cannot drop because it will rest on G, and if A is then energized, raising B, E will still be held up by the pawl G, because the friction between the projection and the

dog is sufficient to overcome the effect of the counterweight. When D is again energized, the weight of E is removed from G, which at once assumes its normal position. Pawl H acts in like manner on armature B. Each armature is fitted with four front and four back contacts.

The interlocking relay shown in Fig. 2127 consists essentially of two ordinary track relays, mounted side by side on the same base. To each armature is fastened a locking arm, which moves up or down as the magnets are energized or de-energized. Near the outer end of these arms and operated by their movement are

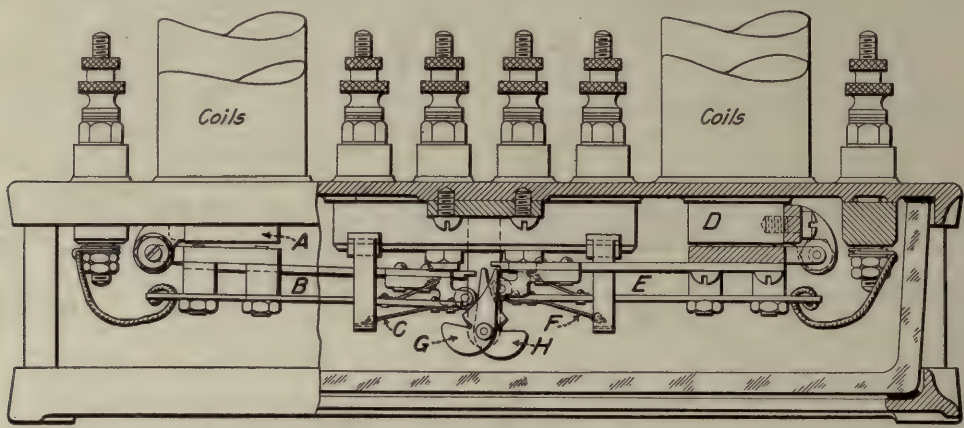


Fig. 2124. Enclosed Interlocking Relay.

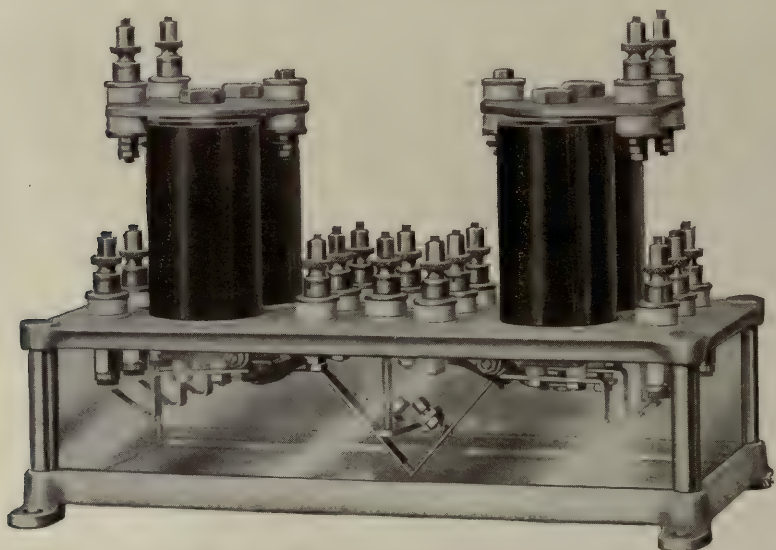


Fig. 2125. Enclosed Interlocking Relay.

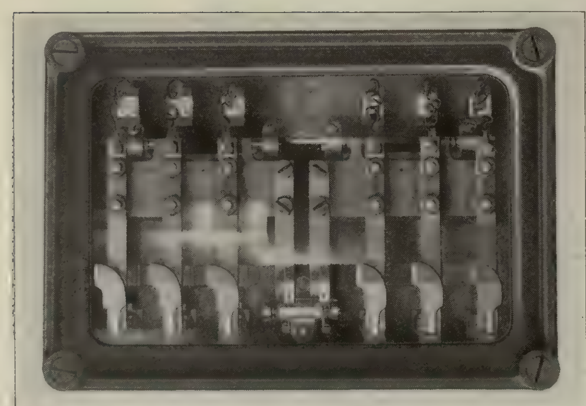


Fig. 2126. Bottom View of Hall Interlocking Relay. Hall Signal Company.

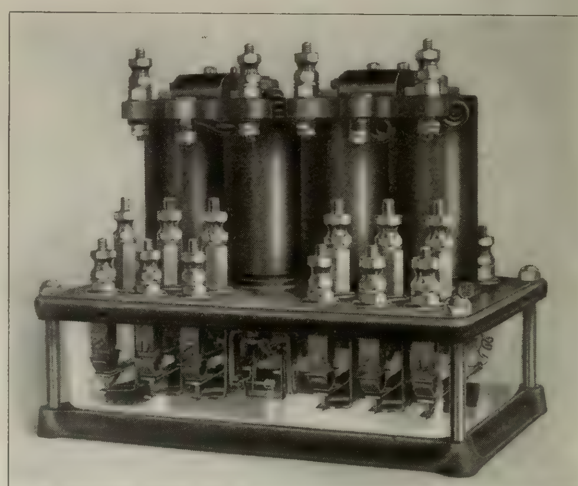


Fig. 2127. Interlocking Relay. Hall Signal Company.

The relay shown in Fig. 2125 accomplishes the same results as those already described, but in a different manner. The two arms extend diagonally from the armatures, and, meeting in the center, are so arranged to interlock with each other that when one armature rings the bell the other is not permitted to do so, until both are restored to their normal position. This relay is fitted with three front and three back contacts in addition to the one that rings the bell.

suspended two locking dogs, one for each arm. These dogs are pivoted and counterweighted in such a manner that when both locking arms are raised both dogs are released and swing outward by gravity. If while in this position either armature should drop, for instance armature No. 1, the locking arm of that armature would strike projecting portion of opposing locking dog, causing dog to swing back under the locking arm of armature No. 2 far enough to interfere with its dropping

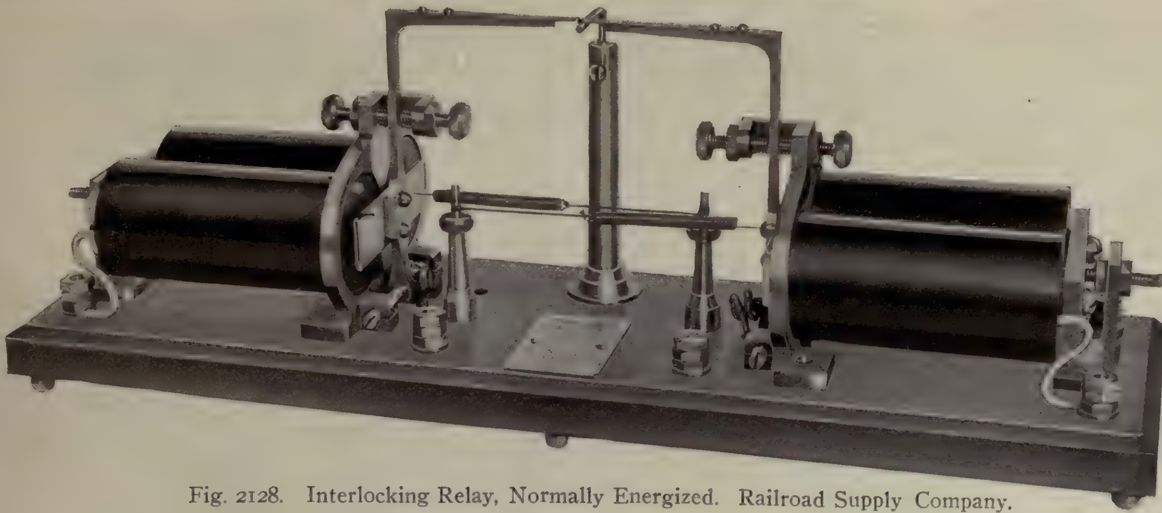


Fig. 2128. Interlocking Relay, Normally Energized. Railroad Supply Company.

sufficiently to make a back contact. Before armature No. 2 can make a full drop both armatures must be lifted to their normal position, when the dropping of either one will prevent the other from making a full drop until both are again raised to their normal position.

BRYANT ZINC INTERLOCKING RELAY.

Fig. 2139 shows a relay of standard construction with the exception of the interlocking feature, which consists of two small, flat, brass hooks, which are suspended so that they are overbalanced and stand normally in one position. To each

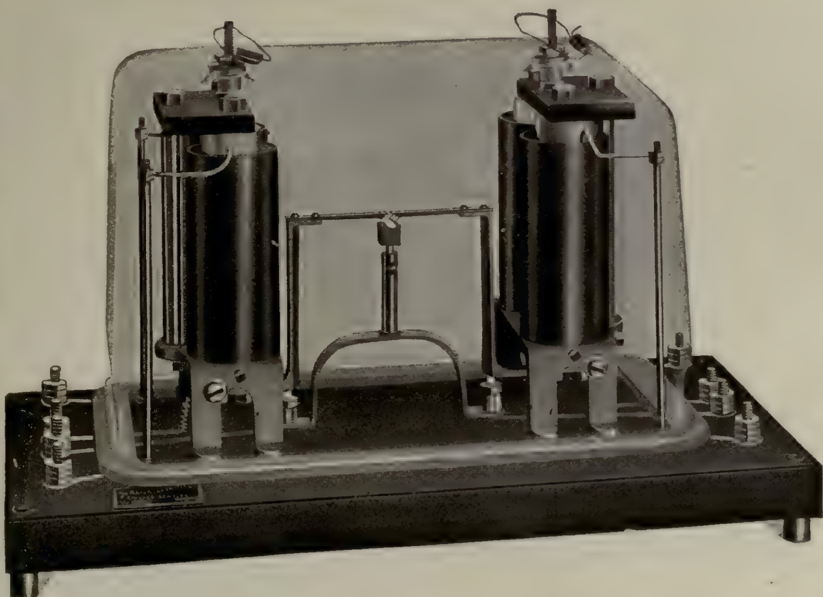


Fig. 2129. Style "HH" Interlocking Relay with One Interlocking Contact. Railroad Supply Company.

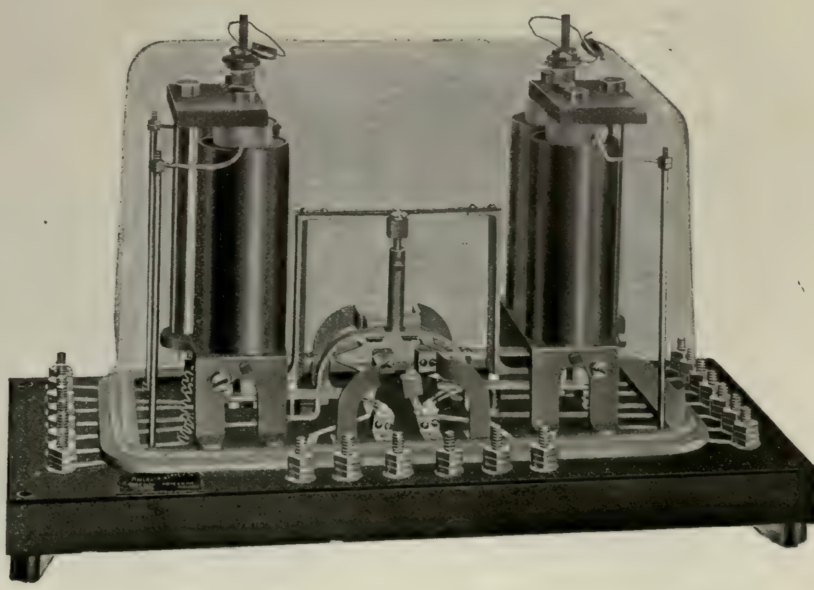


Fig. 2130. Style "HH" Interlocking Relay with One Interlocking Contact and Four Front and Four Back Contacts.

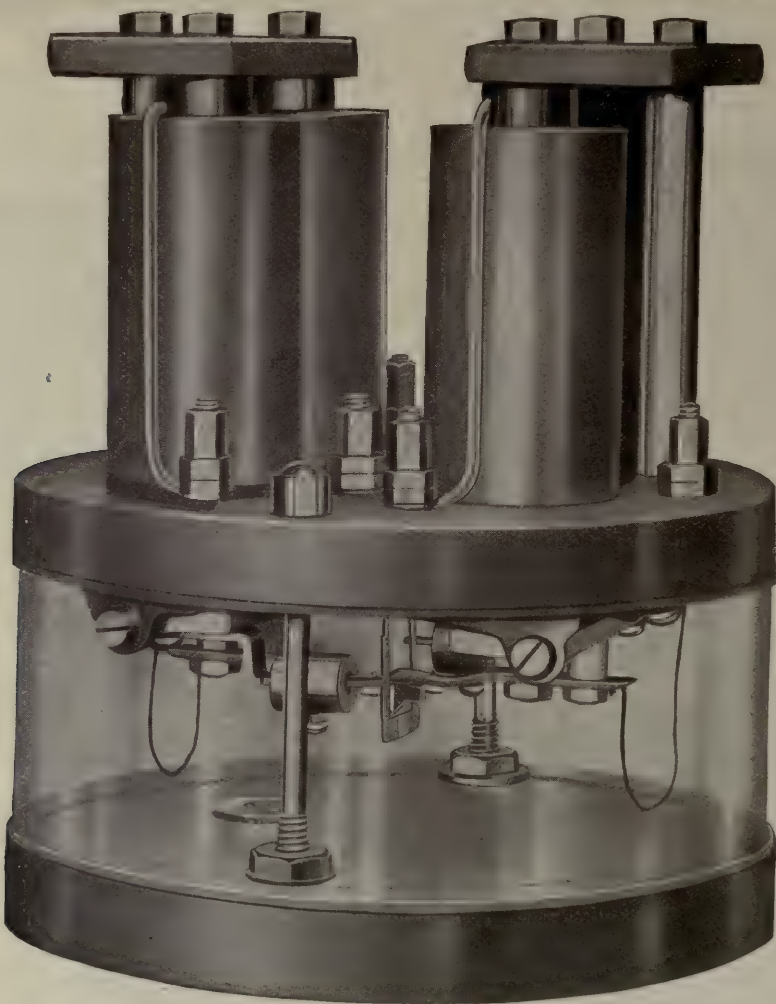


Fig. 2132. Style "E" Interlocking Relay. Railroad Supply Company.

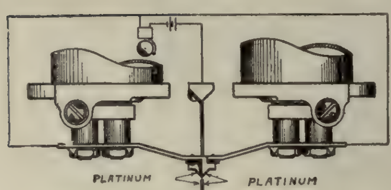


Fig. 2133. Normal Condition. No Trains on Either Track Circuit. Bell Not Ringing.

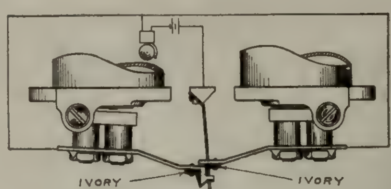


Fig. 2134. Train on Left Track Circuit. One Armature Released, with Platinum Against Platinum Back Contact. Bell Ringing.

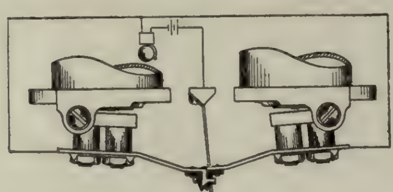


Fig. 2135. Train at Crossing Occupying Both Track Circuits. Both Armatures Released. Bell Ringing.

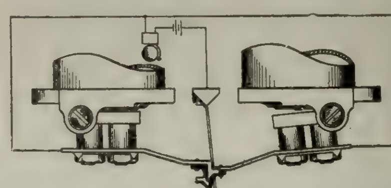
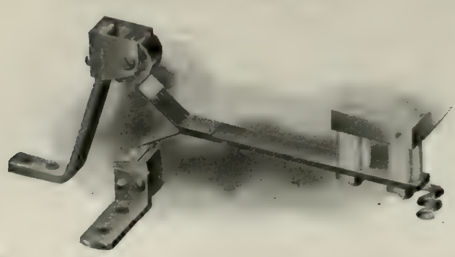
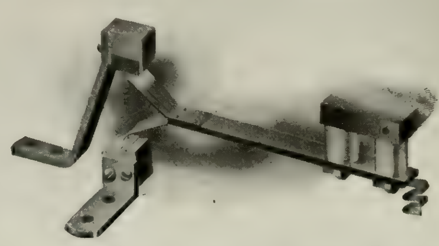


Fig. 2136. Train Past Crossing and Occupying Right Track Circuit. One Armature Normal. Other Armature Resting Ivory Point Against Back Contact. Bell Stopped.

Figs. 2133-2136. Operation of Contact Fingers. Style "E" Relay. Railroad Supply Company.





Figs. 2137-2138. Armature and Contact Arrangements. Style "W W" Relay. Railroad Supply Company.

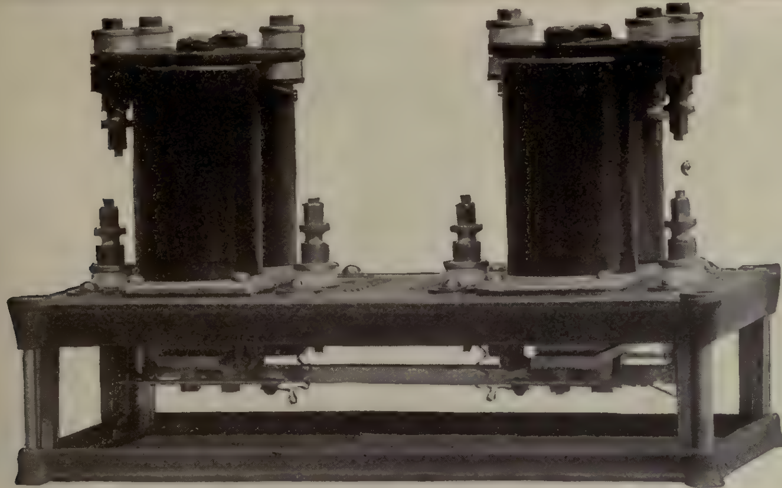


Fig. 2139. Interlocking Relay. Bryant Zinc Company.

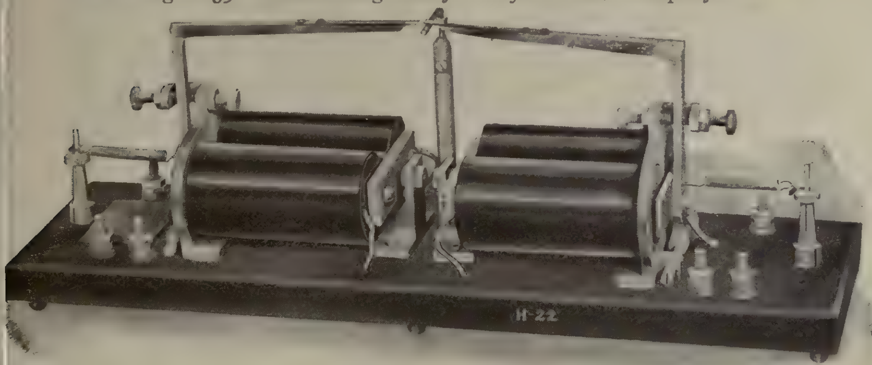


Fig. 2140. Interlocking Relay. Normally De-energized. Railroad Supply Company.

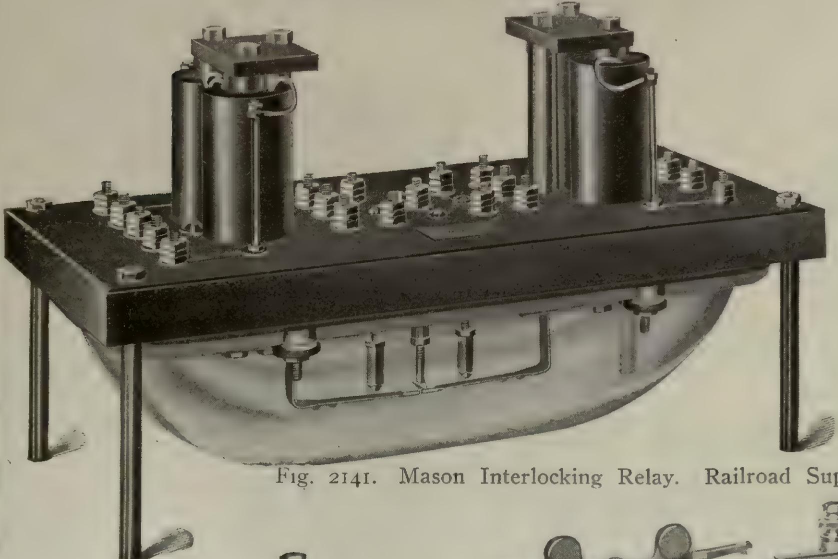


Fig. 2141. Mason Interlocking Relay. Railroad Supply Company.

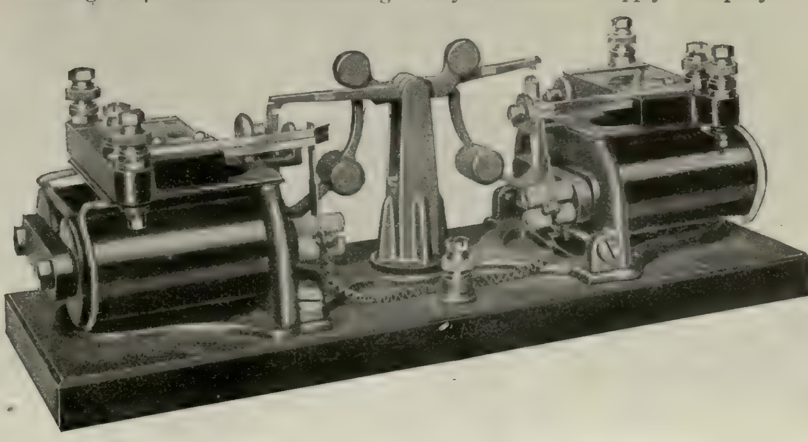


Fig. 2143. Open Type Interlocking Relay. United Electric Apparatus Company.

armature is rigidly attached an aluminum arm, which engages the hook at the other end of the frame of the relay. None of the interlocking parts are used as a part of the circuit.

Under normal conditions, with both sets of coils energized, the two aluminum arms are held out of the way of the brass hooks. The dropping of either armature will raise the aluminum arm until it engages the hook, which will be moved to such a position that it is directly under the armature which is still energized. If at this time the second set of coils is de-energized its armature will drop and rest on the brass hooks, which hold it in such a position that the back contact is not made. If the first set of coils is again energized, its armature will be attracted; the aluminum arm will be moved downward away from the hook, which is now held in place by the armature of the second set of coils, which coils are still de-energized.

Current now being applied to the second set of coils, will raise its armature, thus allowing the hook to resume its normal position.

The standard resistance is four ohms.

Fig. 2142. One-Way Ivory Contact Points, Railroad Supply Company.

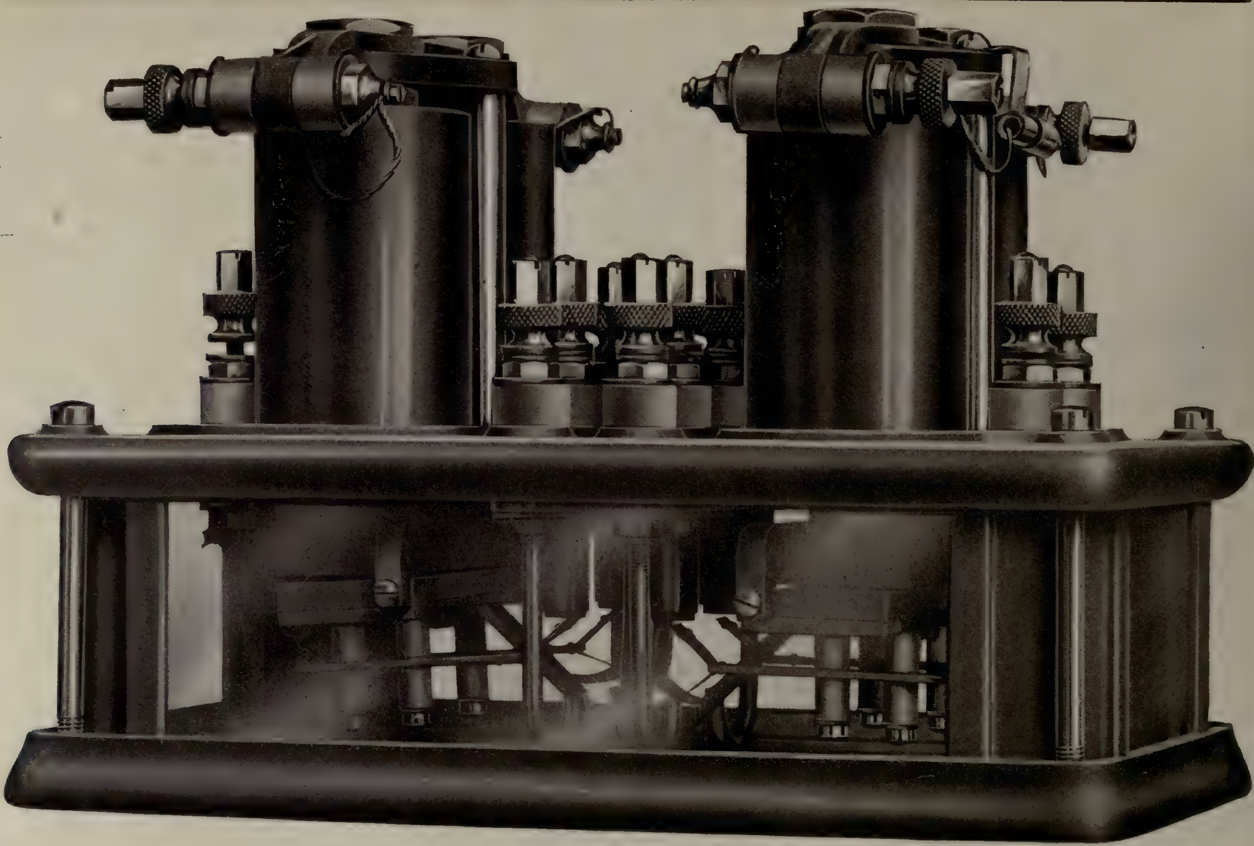


Fig. 2144. Enclosed Universal Interlocking Relay.

UNION UNIVERSAL INTERLOCKING RELAY.

Fig. 2144 shows the enclosed "Universal" interlocking relay made by the Union Switch & Signal Co. It consists essentially of two ordinary relays mounted on one base. In this instrument, however, the contact points project beyond the hinged side of the armature. Thus the back contacts are above and the front contacts below. The interlocking device consists of two arms, one projecting from each armature, which strike against a pivoted pawl. All movable parts are enclosed in a dust-proof case, forming the base of the relay.

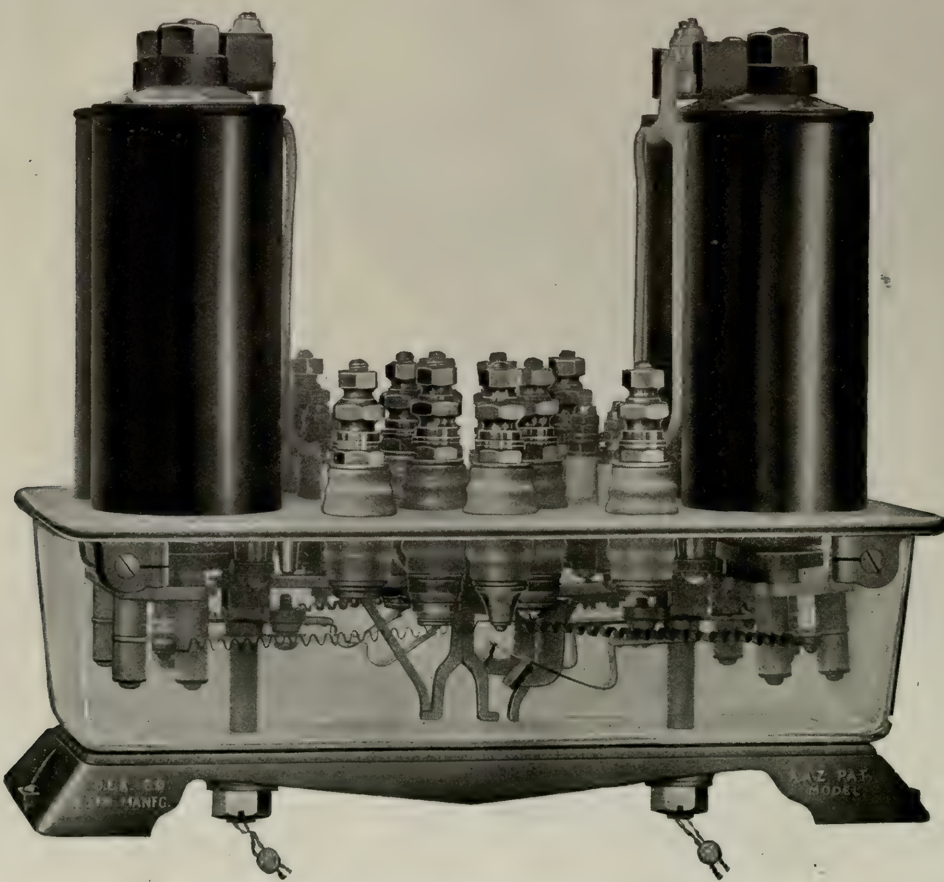


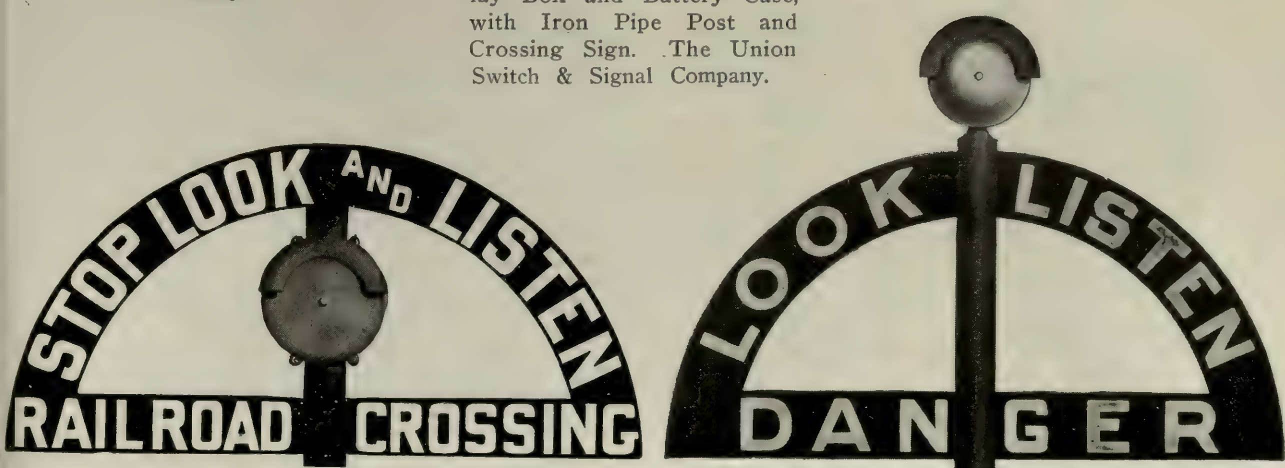
Fig. 2145. Enclosed Type Interlocking Relay. United Electric Apparatus Company.

SIGNS AND BELLS.

Fig. 2146. Crossing Signal Complete, with Double Gong Enclosed Bell, and Sign. American Railway Signal Company.

Fig. 2147. Crossing Bell, Relay Box and Battery Case, with Iron Pipe Post and Crossing Sign. The Union Switch & Signal Company.

Fig. 2148. Crossing Bell and Relay Box on Iron Post, with Crossing Sign. Bryant Zinc Company.



Figs. 2149-2150. Signs and Bells. (These can be Mounted on any Post.) Bryant Zinc Company.

Fig. 2151. Crossing Bell and Relay Box on Iron Post, with Sign. Bryant Zinc Company.

Fig. 2152. Bell and Relay Box on Iron Post, with Sign. Bryant Zinc Company.

Fig. 2153. Bell and Relay Box on Iron Post, with Sign. Bryant Zinc Company.

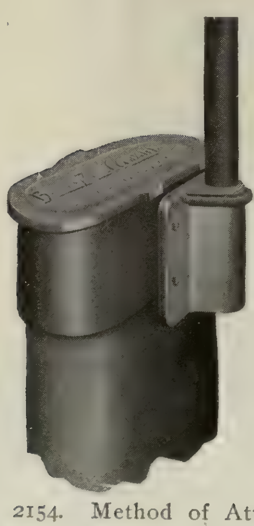


Fig. 2154. Method of Attaching Bell Post to Battery Chutes. Bryant Zinc Company.

Fig. 2155. Bell Sign and Relay Box. Railroad Supply Company.

ILLUMINATED HIGHWAY CROSSING SIGNALS.

Figs. 2160 and 2161 show two types of illuminated highway crossing alarm signals which are manufactured by the Bryant Zinc Co.

The sign shown in Fig. 2161 consists of an iron box in the sides of which is cast the word "danger" in seven-inch letters. A special heavy-wired, ribbed plate glass is used for the display of the sign.

This sign is made in two parts, which are bolted to the pole. Each side is lighted by a six-volt, two-candle-power tungsten lamp. The current consumption of these lamps is 420 milli-amperes each, or 840 milli-amperes for the sign. The length over all is 35 inches. The letters can be made to show in either red or white.

The energy for operating the lights is supplied by the bell battery, the lights being connected up in multiple with the bell mechanism.

Fig. 2160 illustrates another method of illuminating a highway crossing sign. Two heavy case reflector hoods are supported over the sign in such position that a clear white light is thrown on the letters of the sign, making it readable at night. The hoods are fastened to a steel pipe, which screws into an iron collar, which fits over the top of the pole. The reflector is protected by heavy wired glass and the entire hood is weatherproof. Each reflector contains a six-volt two-candle-power tungsten lamp. This illuminated signal has the same current consumption as the signal in Fig. 2161, viz., 420 milli-amperes per bell, or a total of 820 milli-amperes. The lights are in multiple with the bell as in Fig. 2161.

Fig. 2156.

Fig. 2157.

Fig. 2158.

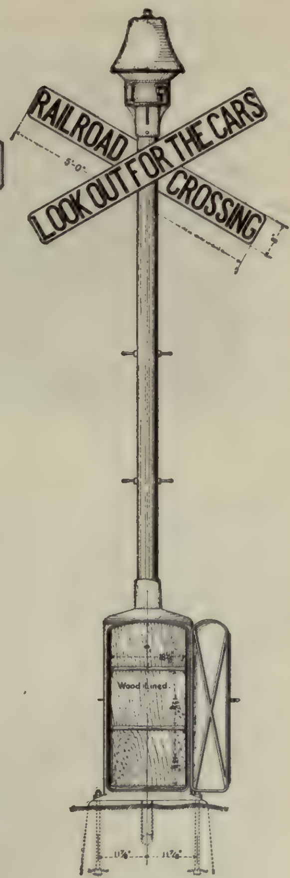
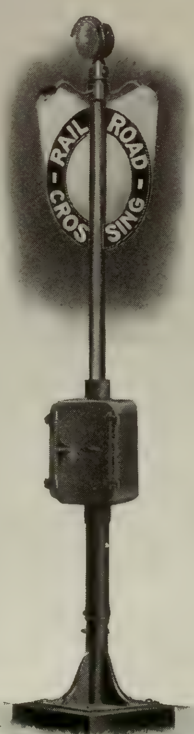
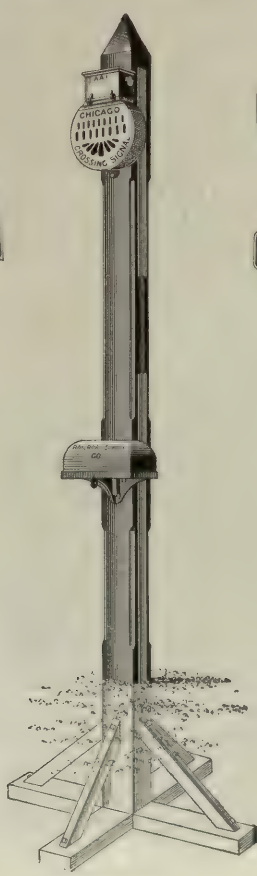


Fig. 2159.

Figs. 2156-2159. Locomotive Type Highway Crossing Bells Showing Various Forms of Signs, and Attachments. Railroad Supply Company.



Figs. 2160-2161. Illuminated Highway Crossing Signals. Bryant Zinc Company.



Figs. 2162-2163. Bells, Posts and Signs. Railroad Supply Company.

Fig. 2164. Illuminated Highway Crossing Signal. C. F. Massey Company.

Fig. 2165. Illuminated Highway Crossing Signal. C. F. Massey Company.

MASSEY ILLUMINATED CROSSING SIGNAL.

This signal consists of a re-inforced concrete pole with relay box and bronze disk danger sign. Conduit leads are embedded in the center of the pole from the base to the relay box and from the box to the lamp. The lamp is fastened between the bronze discs so that when there is a train at the crossing a red light is displayed behind words indicating danger. The batteries are housed in the battery well at the base of the pole. The height of the pole above the rail is 16 ft., and the disc is 2 ft. 6 in. in diameter. The light is in multiple with the bell and is thus operated from the same batteries. Figs. 2164 and 2165 are views of the illuminated crossing signal in service; and Figs. 2166 and 2167 show the signals with a different equipment of bell and sign. In the latter figures the Railroad Supply Co.'s locomotive type bell is made use of. The crossing signals are made of reinforced cement, both the relay boxes and the circular head which carries the illuminated disk being reinforced throughout. The usual arrangement of the lights is such that the warning sign is visible to the user of the road approaching the crossing from either direction.

Fig. 2166. Illuminated Highway Crossing Signal. C. F. Massey Company. (Using Railroad Supply Company's Locomotive Type Bell.)

Fig. 2167. Reinforced Concrete Crossing Signal. C. F. Massey Company. (Using Railroad Supply Company's Locomotive Type Bell.)

Figs. 2168-2169. Bells and Posts. Showing Two Methods of Supporting. (Bell Posts are made of I Beams.) Railroad Supply Company.

Fig. 2170. Model "A" Faraday "High-Power" Enclosed Type Gong. Stanley & Patterson.

Fig. 2171. Model "B" Faraday "High-Power" Enclosed Type Gong. Stanley & Patterson.

Fig. 2172. Model "CC" "High-Power" Enclosed Type Gong. Stanley & Patterson.

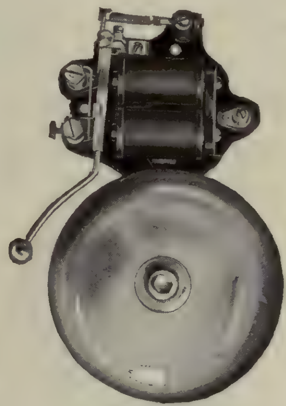


Fig. 2173. Faraday "High-Power" Skeleton Bell. Stanley & Patterson.

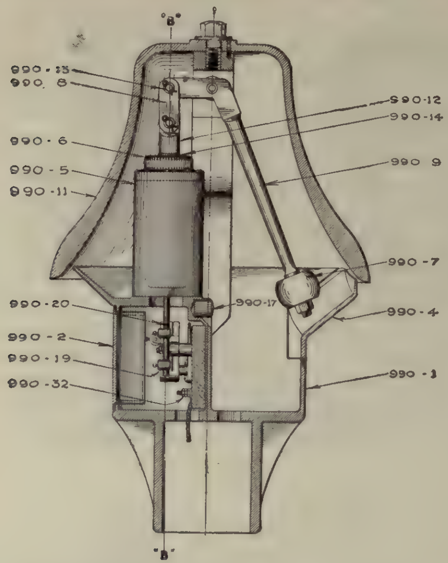
ENCLOSED CROSSING BELLS.

Figs. 2174 and 2175 show the enclosed type of crossing bell made by the Bryant Zinc Co. The movement is enclosed in a dust and weatherproof case. All moving parts are held in place by spring cotters. Contacts are platinum to platinum. The standard winding of magnets is 10 ohms. These bells can be operated on any circuit from two volts to 650 volts.

The style A bell is designed for mounting to side of post or building. The style B bell is designed to be placed on top of a 3 in., 3½ in. or 4 in. pipe post. The gong is 12 in. in diameter.

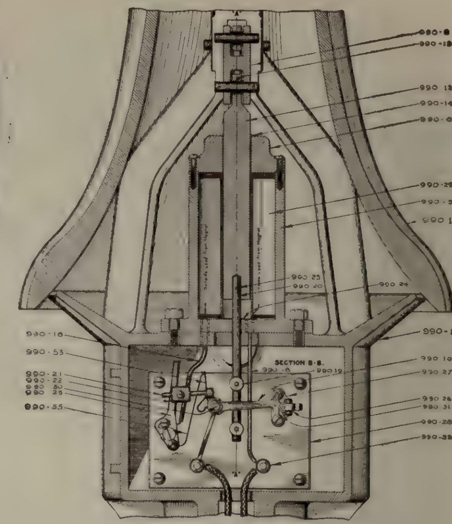
Fig. 2174. Bell for Side of Pole. Bryant Zinc Company.

Fig. 2175. Bell for Top of Pole. Bryant Zinc Company.



Section.

Complete Bell.



Section Through Magnet.

Figs. 2176-2178. Locomotive Type Crossing Bell, Showing Two Views of Its Operating Mechanism. Railroad Supply Company.

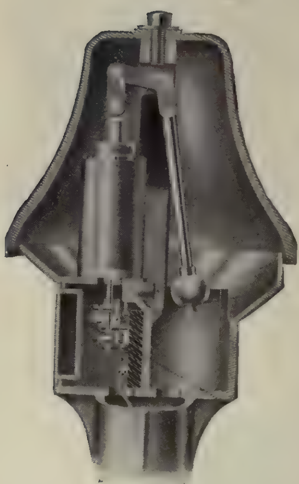


Fig. 2179. Sectional View of Locomotive Type Bell Mechanism.

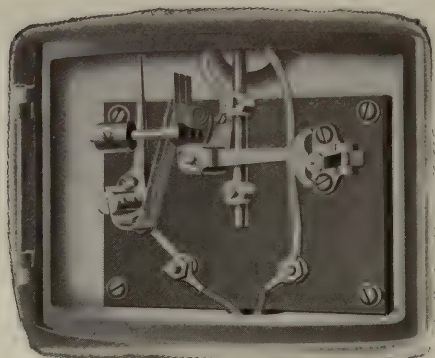


Fig. 2180. Operating Mechanism of Locomotive Type Bell.

Fig. 2181. Chicago Highway Crossing Signal Style "AA." Railroad Supply Company.

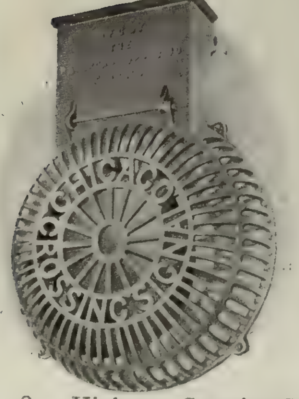


Fig. 2182. Highway Crossing Bell Style "A." Railroad Supply Company.

Fig. 2183. Style "CC" Bell for Top of Post. Railroad Supply Company.

Fig. 2184. Style "CC" Bell for Side of Post. Railroad Supply Company.

Fig. 2185. Style "C" Bell with Fittings to Clamp to Top of Post. Railroad Supply Company.

Figs. 2186-2189. Style "C" Bell Mechanism and Parts. Railroad Supply Company.

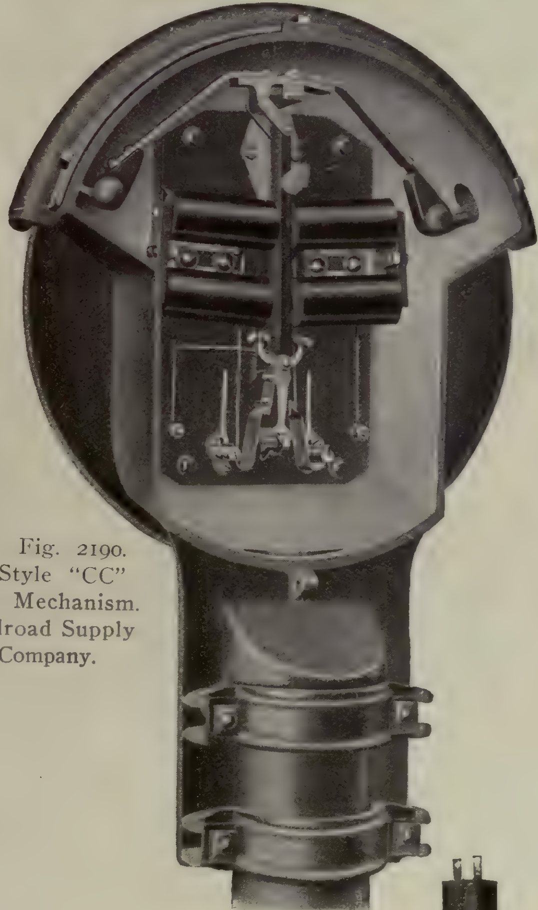


Fig. 2190. Style "CC" Bell Mechanism. Railroad Supply Company.

Fig. 2191. Iron Case, Enclosed Crossing Bell. United Electric Apparatus Company.

Fig. 2192. Enclosed Water Tight, Low and High Voltage Highway Crossing Bell. United Electric Apparatus Company.

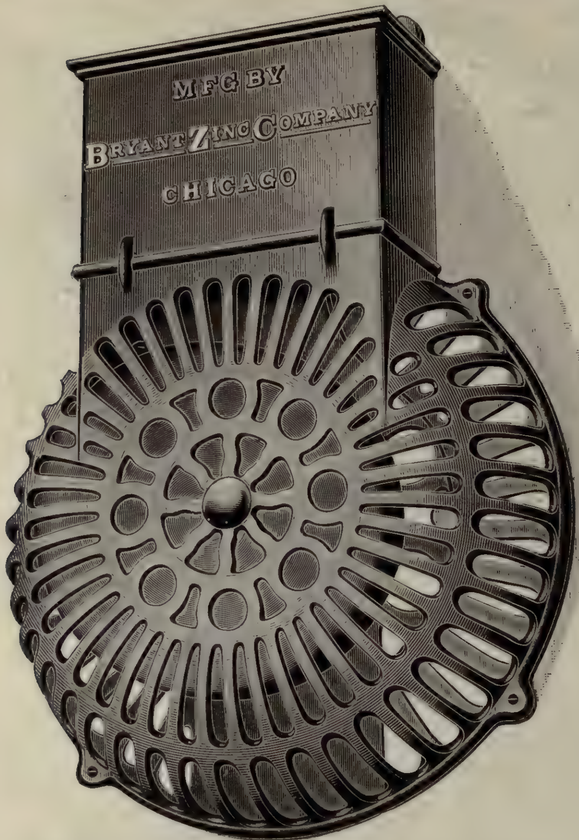
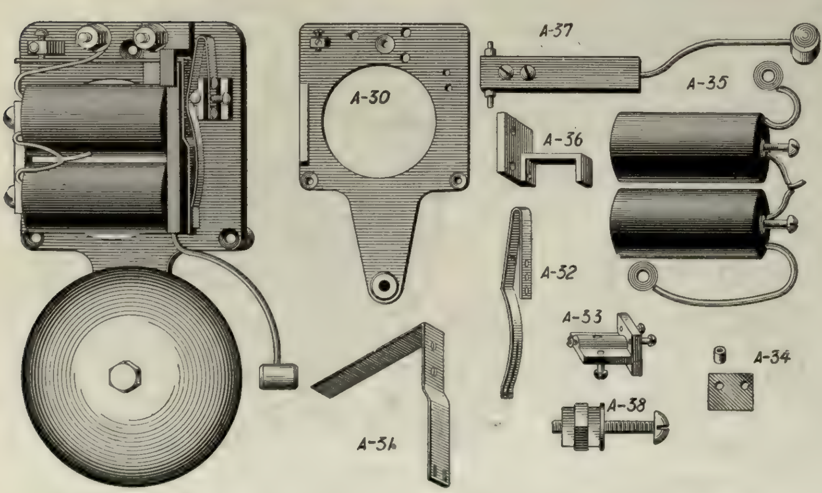


Fig. 2193. Crossing Bell. Bryant Zinc Company.

Figs. 2194-2195. Bell and Case. Railroad Supply Company.

Fig. 2196. Illuminated Signal for Highway Crossing Signals. Railroad Supply Company.

Note.—The Illuminated Signal, Fig. 2196, is Made to Fit the Standard Bell Posts, Which Are Shown in Figs. 2156-2159.



Figs. 2197-2206. Style "A" Skeleton Bell Parts. Railroad Supply Company.

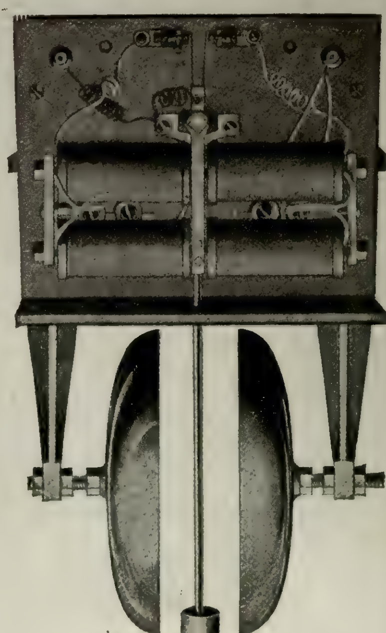
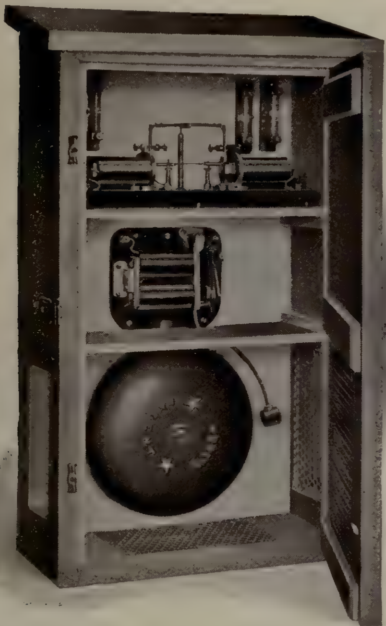


Fig. 2207. Double Gong Bell.



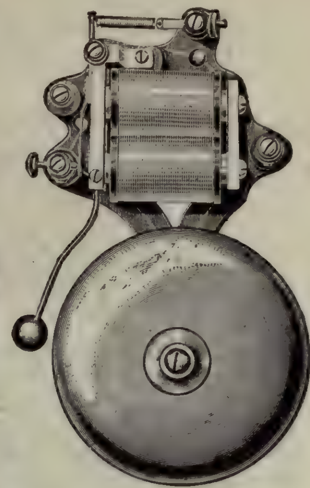


Fig. 2210. Style "X" Skeleton Bell. Railroad Supply Company.

Figs. 2208-2209. Combination Bell and Relay Box. Railroad Supply Company.

CLOCKWORK BELL OPERATING MECHANISM.

In Figs. 2211 and 2212 the clockwork mechanism is actuated by the train passing over a short track circuit or a track instrument (see "Circuit Controllers") situated at a suitable distance from the crossing.

The connection between the starting point and the relay or "register" is made by line wires, and the instrument is set so as to keep the bell circuit closed a predetermined length of time, which can be varied from 20 seconds to three minutes, as may be convenient.

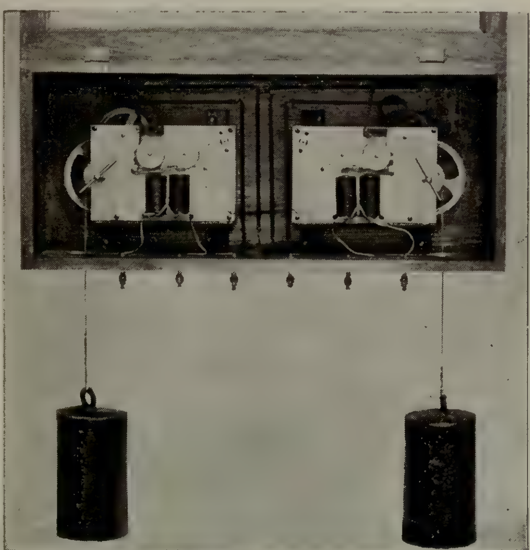


Fig. 2211. The O'Neill "Register," a Clockwork Mechanism, Performing the Same Kind of Work as the Relay Shown in Fig. 2212. Railroad Supply Company.

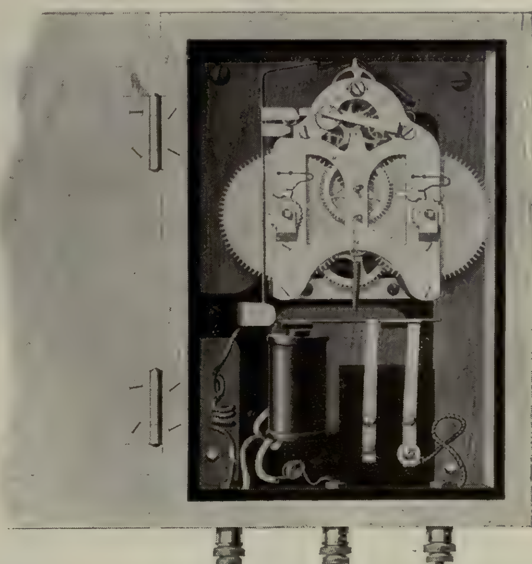


Fig. 2212. Escapement Relay. Railroad Supply Company.

Figs. 2213-2214. Electric Light for Highway Crossing Signal.

Fig. 2215. Double Gong Highway Crossing Bell. Railroad Supply Company.

Fig. 2216. Iron Crossing Sign and Instrument Case. Bryant Zinc Company.

Fig. 2217. Cast Iron Bell Case and Cover. The Union Switch and Signal Company.

Fig. 2218. Cast Iron Bell Case and Cover. The Union Switch and Signal Company.

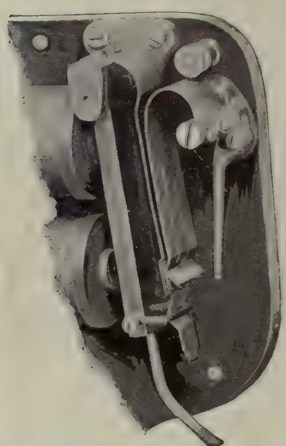


Fig. 2219. Bell Armature and Contacts. The Railroad Supply Company.

Fig. 2220. Bell Mounted in Cast Iron Case. The Railroad Supply Company.

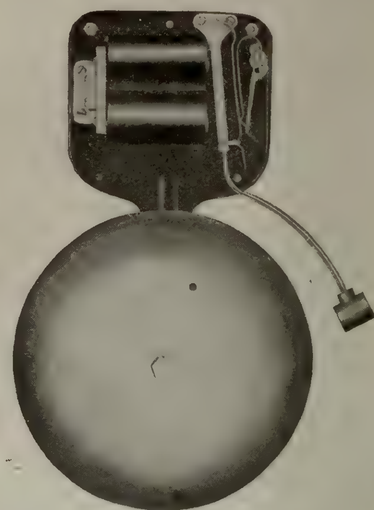


Fig. 2221. Skeleton Frame Bell, with 12-in. Gong. The Railroad Supply Company.

Fig. 2222. Crossing Bell, with 12-in. Steel Gong, Enclosed Mechanism, for Use on Iron Pipe Post. The Union Switch & Signal Company.

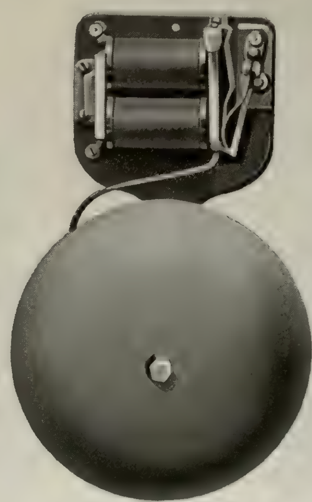


Fig. 2223, Bell. with 12-in. Steel Gong. The Union Switch & Signal Company.

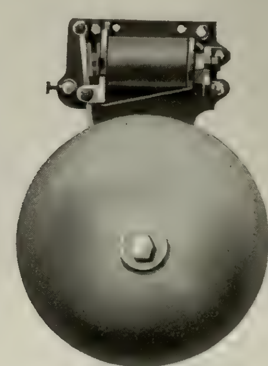


Fig. 2224. Bell, with 10-in. Steel Gong. The Union Switch & Signal Company.

Fig. 2225. Highway Crossing Alarm. Hall Signal Co.

Fig. 2226. Electric Crossing Gate. Lake Shore & Michigan Southern Railway. General Railway Signal Company.

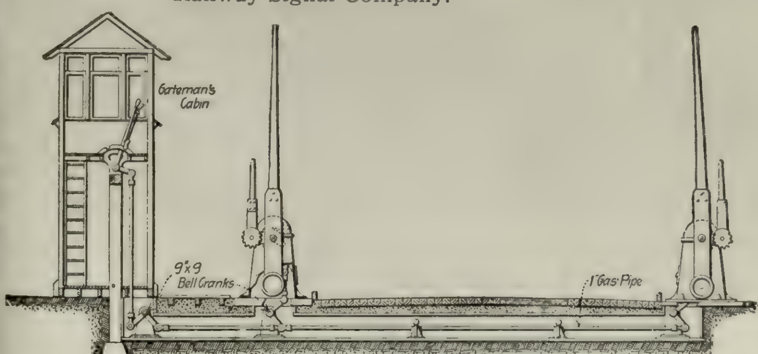


Fig. 2227. Crossing Gate Mechanism. Railroad Supply Company.

THE UNION ELECTRIC CROSSING GATE.

The crossing gate illustrated is built in any required length up to 50 ft. either with or without sidewalk arms. The wooden arms are well braced and trussed, and are provided with spring stop rods to cushion the blow when the gate comes to the horizontal stop position.

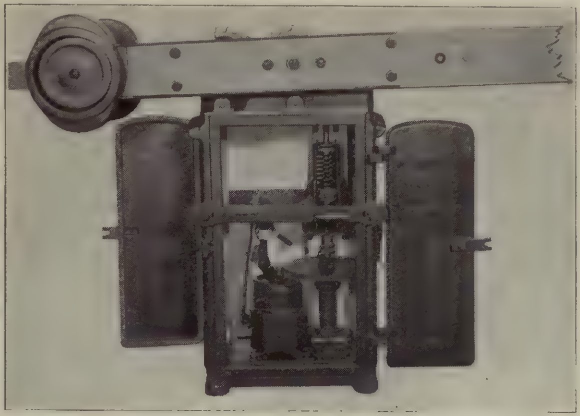


Fig. 2228. Electric Crossing Gate. Union Switch & Signal Company.

The mechanism is mounted in a strong cast-iron case provided with doors so that the mechanism is easily accessible.

The gate motor illustrated is operated by 110-volt d. c. current and is controlled by a double-pole, double-throw switch. The motor may be either a. c. or d. c., the standard for d. c. work being 110 volts, and for a. c. work 110 volts, 25 or 60-cycle, single-phase.

Fig. 2229. G. R. S. Model "2A" Crossing Signal, Showing Control Battery and Case. Long Island Railroad.

Fig. 2230. Highway Crossing Signal Using Model "2A" Mechanism.

Fig. 2231. Highway Crossing Alarm Using Hall Disk Signal. Hall Signal Company.

TRACK INSTRUMENT CROSSING SIGNAL.

HOESCHEN SYSTEM.

The motive power used to operate this bell is obtained from the natural spring of the rail, which is utilized by means of levers placed under the base of the rail.

Seven different types of this signal are made. Where crossings adjacent to stations are protected, or where more or less switching is done, it is possible to place the starting generators so that the bell does not ring when the train is standing on the main track during the time the engine is switching in the yards. The bell automatically cuts out when the train comes to a standstill, and does not begin to ring again until the train is in motion, approaching the crossing.

The type "50-B" bell is especially designed for use on double track as it continues to ring as long as there is a train in motion approaching the crossing on either track.

An illuminated sign which will remain illuminated only while the bell is ringing may be used in connection with these bells.

Fig. 2232 is a general view of the selective magneto generator installed ready for operation. Any number of these generators may be placed the desired distance each way from the crossing on the track or tracks to be protected. They are connected in series with the releasing magnets controlling the bell motor by a metallic circuit.

Fig. 2232. Selective Magneto Generator Installed Ready for Operation. Hoeschen Manufacturing Company.

Figs. 2233-2235 shows the selective magneto generator with cover "A" removed.

"B" represents the armature at rest on the induction coils "C" "C," which are fastened to the poles of a group of three permanent magnets "D" "D."

"E" represents the armature rocker tripping pin, which rests on the upper ends of the two vertical rods "F" and "G;" the lower ends of which rest on top of the ends of scale levers "O" and "S," which are termed "operating" and "shunt," and are placed in a "V" shaped position with their outer ends resting firmly against the under side of rail; their inner ends converging under base of generator supporting rods "G" and "F." These levers being fulcrumed close to the rail multiply the slight depression of the rail (caused by a passing train) which is usually $\frac{1}{16}$ in. at a ratio of 1 to 12, thus giving the inner ends of levers "O" and "S" an upward stroke of about ¾ in., which is sufficient to operate or shunt the generator as may be required.

"K" "K" represent the housings containing spiral compression springs with plungers resting on scale levers "O" and "S" and are used to increase or decrease the tension of these levers.

Two line wires lead out from the induction coils on the opposite side through a lightning arrester, thence to wires "W" "W," which are trunked to the telegraph line, thence to the bell.

"S" "S" represent heavy spiral springs, which are placed on the two bolts holding the generator base to the cross plank "P." These springs protect the mechanism from excessive vibration, which may be caused by flat wheels pounding the rail directly over the levers "O" and "S."

Fig. 2234 shows the selective magneto generator as operated by a car or train moving toward the bell. As a car or train, mov-

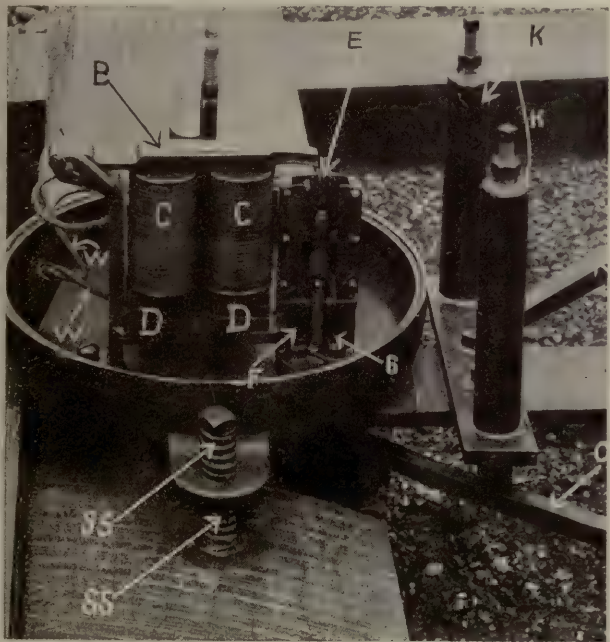


Fig. 2233. Selective Magneto Generator with Cover Removed Showing Mechanism. Hoeschen Manufacturing Company.

ing toward the crossing, passes over the track opposite the generator, levers "O" and "S" are so arranged that the operating lever is always depressed slightly in advance of the shunt

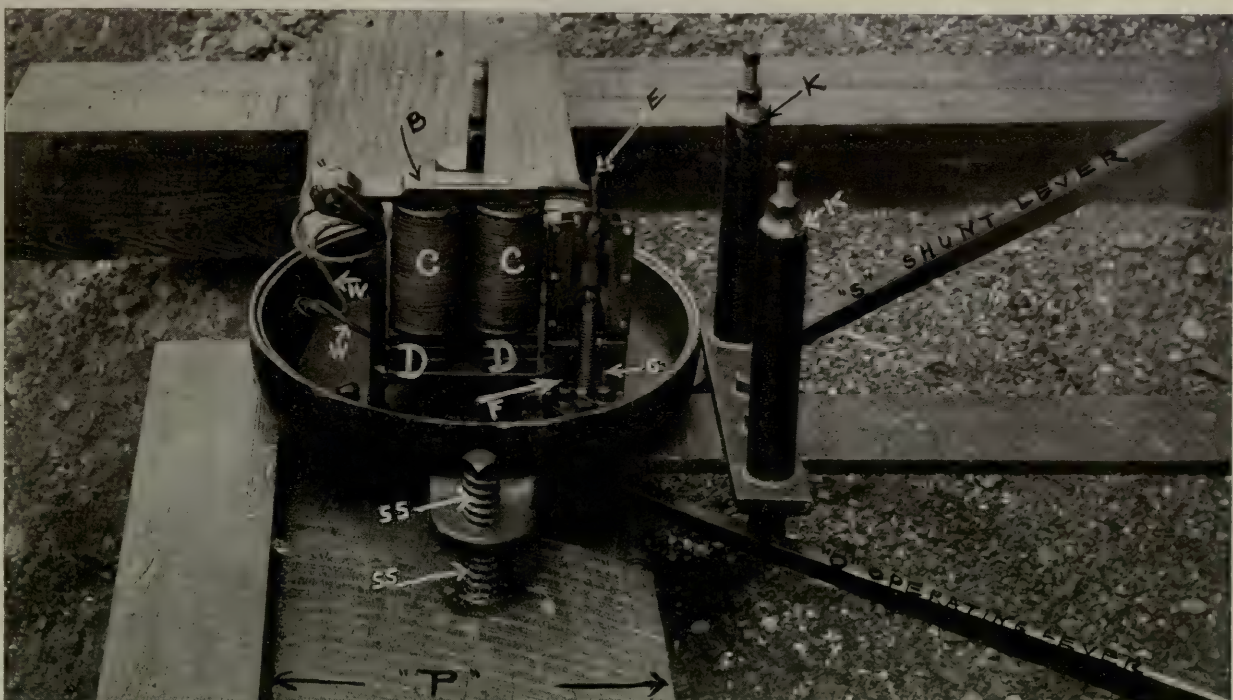


Fig. 2235. Selective Magneto Generator Being Operated by Train Moving Away From the Bell. Rod F Prevents E from Engaging with B, Preventing the Generating of the Momentary Current in Coils CC. Hoeschen Manufacturing Company.

lever. The depression of the operating lever forces the vertical rod "G" upward, thus imparting both an upward and inward motion to the armature rocker tripping pin "E," which brings it in contact with the armature "B" with sufficient force to separate armature "B" quickly from the poles of the induction coils "C" "C," thus generating a momentary current of high voltage which is transmitted over the wires "W" "W" to the releasing magnets of the bell motor.

Fig. 2235 shows the selective magneto generator shunted by a car or train moving in the opposite direction from the bell. As a car or train, moving from the crossing, passes over the track

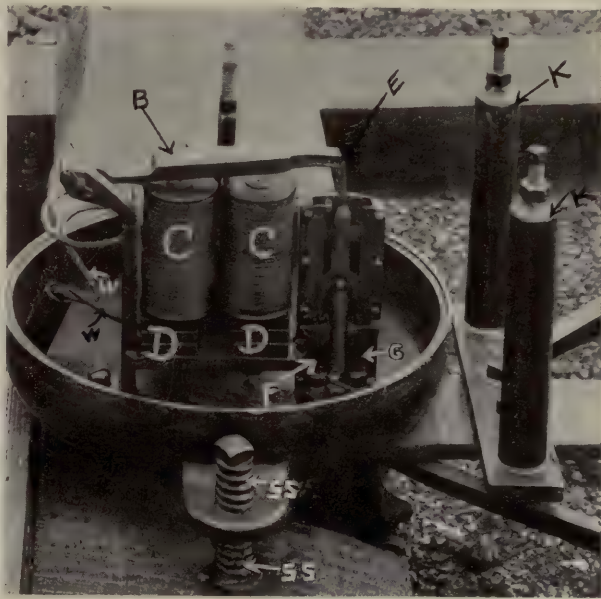


Fig. 2234. Selective Magneto Generator Being Operated by Train Moving Toward the Bell. Hoeschen Manufacturing Company.

opposite the generator, levers "O" and "S" are so arranged that the shunt lever is always depressed slightly in advance of the operating lever. The depression of the shunt lever forces the vertical rod "F" upward, thus imparting both an upward and outward motion to the armature rocker tripping pin "E," which causes it to pass by the end of armature "B" so that the depres-

sion of the operating lever, immediately following, has no actuating effect.

Fig. 2239 shows the bell installed ready for service with the spring motor equipped for single track with both time and automatic cut-out attachments ; also the arrangement of the bell crank levers and connecting rods used to wind the motor. The three-in. pipe housing for the connecting rod from the track to the bell may be lowered and entirely covered with ballast where necessary. The motor is compactly built, and the few parts for its construction consist of a simple gear movement of three wheels used in connection with three powerful motor springs.

Referring to Fig. 2241, the generators are connected in series with the releasing magnets "M" "M" by a separate metallic circuit running each way from the crossing. Each pair of releasing magnets is equipped with a pointed armature "N" "N," ing motion to the rocker "R" "R," which is connected direct by rod "RO" with a pendulum bell hammer, which at regular intervals strikes alternately the inner sides of a loud sounding locomotive type of bell at the rate of 200 strokes per minute for a pre-arranged time unless stopped by a passing train.

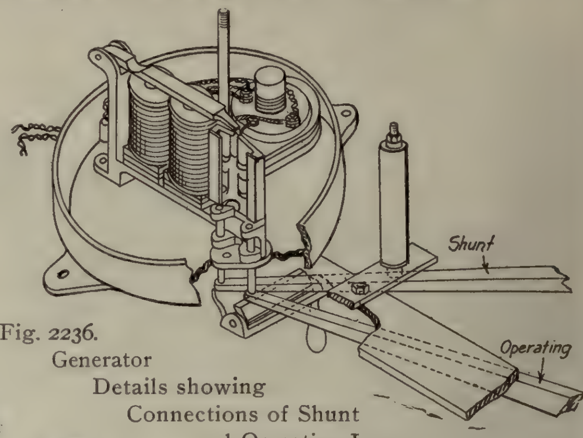


Fig. 2236. Generator Details showing Connections of Shunt and Operating Levers.

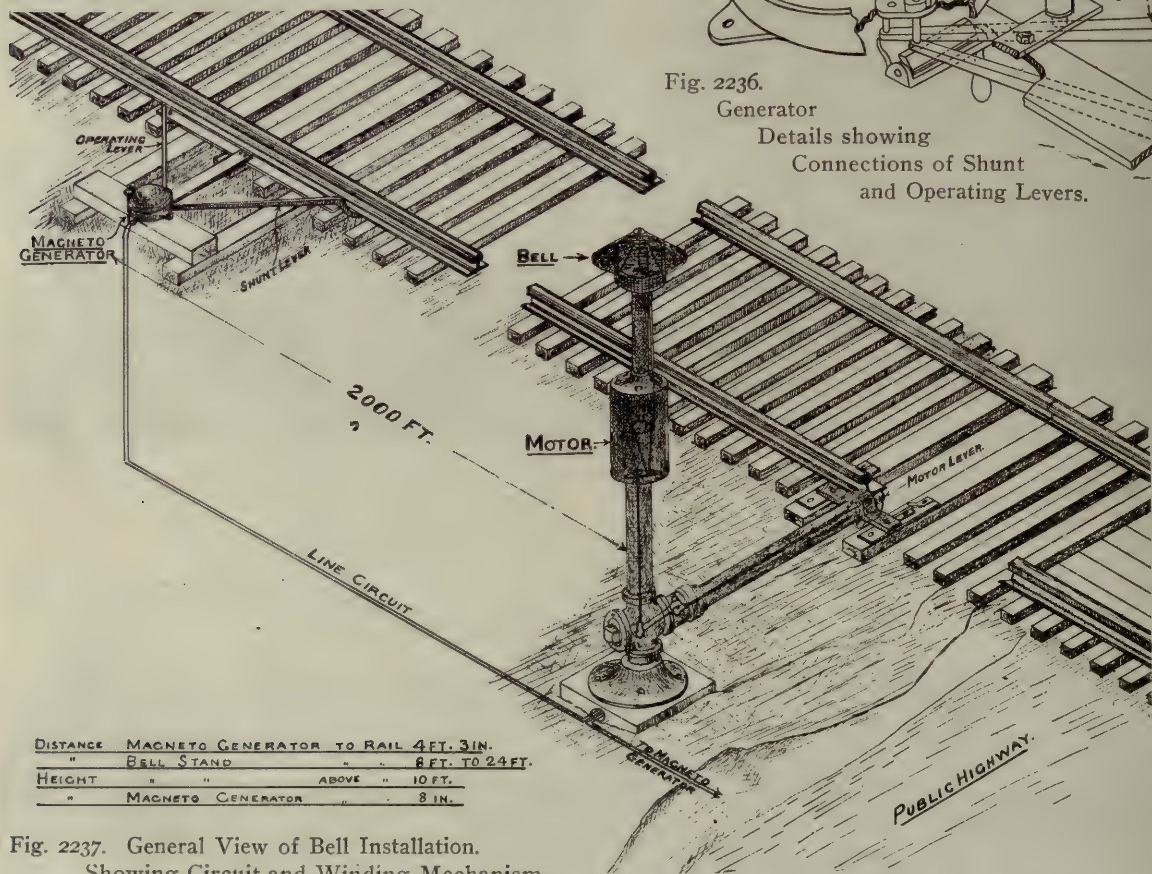


Fig. 2237. General View of Bell Installation. Showing Circuit and Winding Mechanism.

both of which engage the releasing clutch lever "L" in the manner shown. Clutch lever "L" holds the releasing lever "RL" in the position as shown when motor is not in motion. When either of the releasing magnets is energized by the operation

The motor is provided with both an automatic and time-stopping device. The time-stopping arrangement operates as follows:

When the motor is released and the escapement wheel starts

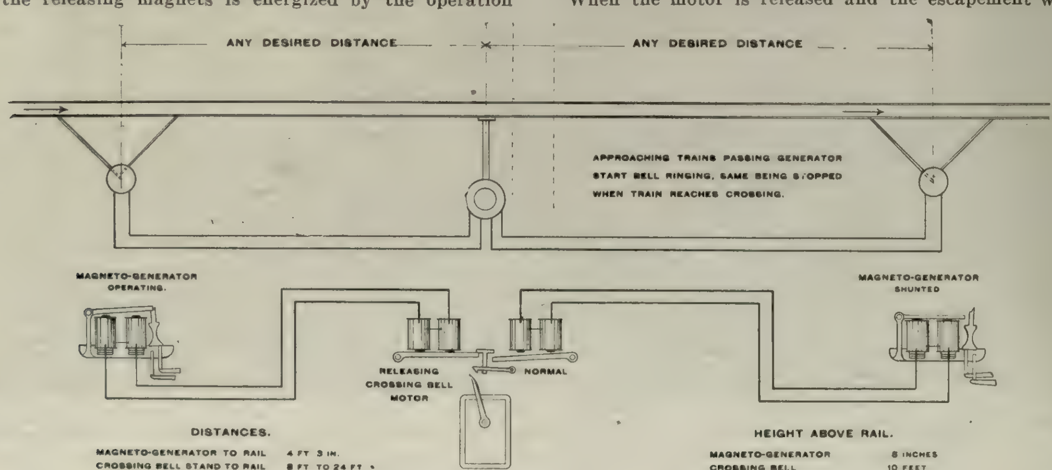


Fig. 2238. Diagram for Single Track Installation of Hoeschen Bell.

of a generator, the armature "N" corresponding lifts the clutch lever "L," thus releasing the motor through lever "RL." As the escapement wheel turns from right to left, it imparts a rock- to turn from right to left, it exerts a slight pressure on a counterweight which is fastened to the inner end of the "RL" lever shaft directly over the escapement wheel. This movement

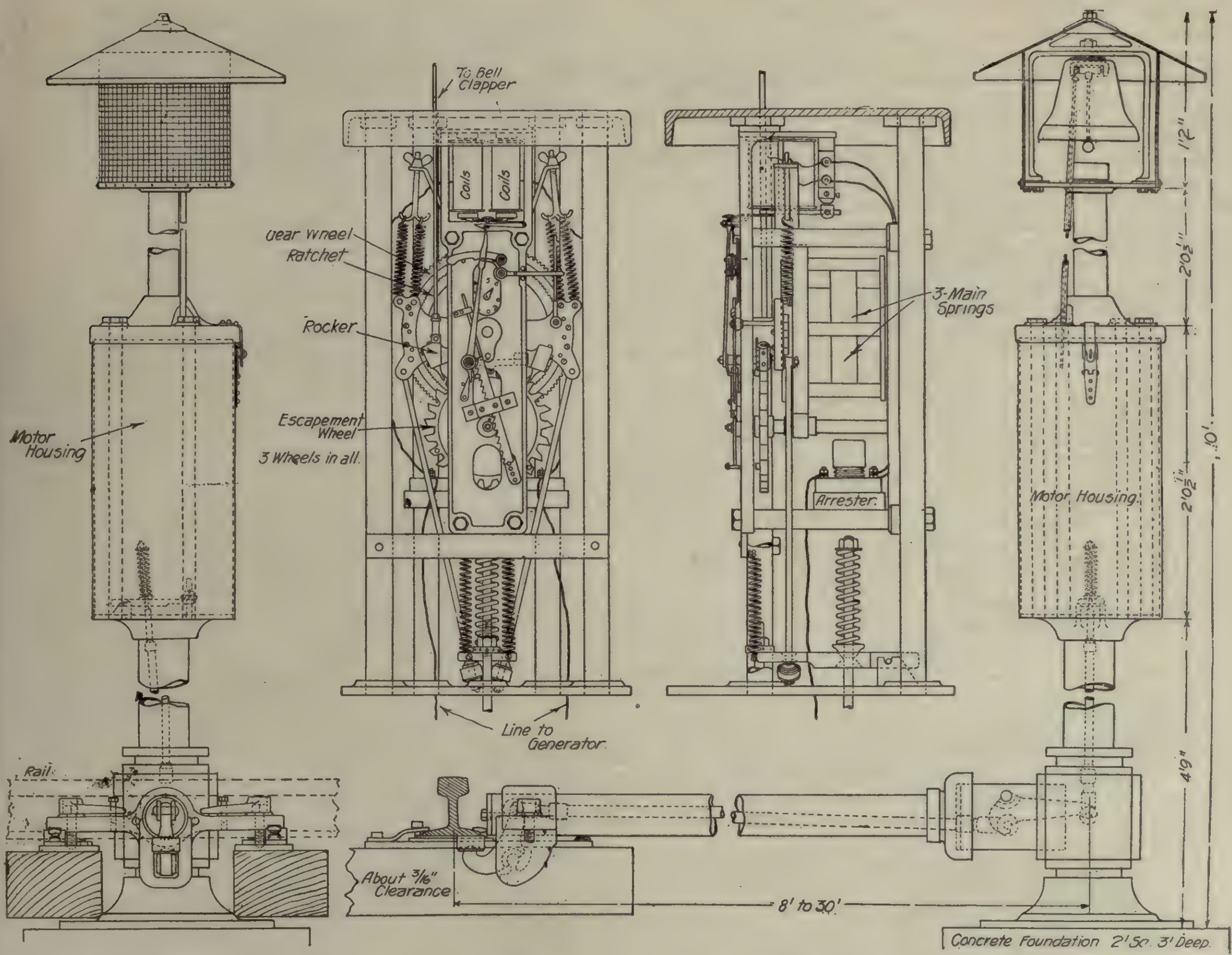


Fig. 2239. Details of Bell, Connections to Rail and Winding Arrangement. Dotted Lines in Pipe Show Winding Rods. Hoeschen Manufacturing Company.

Fig. 2240. Hoeschen Bell on the Illinois Traction System. A Union Style "B" Semaphore Signal of the Type Recently Installed on 500 Miles of the Illinois Traction System Lines is Also Shown at the Left of the View.

forces lever "RL" to move slightly to the left, where it is locked by latch lever "V," and it remains in this position until released by the sliding sawtooth bar "XX," which is elevated one notch or tooth for each revolution of the escapement wheel by means of the small stud on the hub of the escapement wheel, thus causing the upper end of sawtooth bar "XX" to raise lever "V" which allows lever "RL" to swing back to normal by means of the counterweight, thus stopping the motor. The bell can be made to ring for a longer or shorter time by either lowering or raising the sawtooth bar "XX" by means of the set screw in the holes shown directly below it.

The automatic cut-out or stopping mechanism is operated simultaneously with the winding of the motor by a passing train. The slight depression of the rail of 1-32 or 1-16 in., caused by a passing train, imparts a rocking or reciprocating movement of the bell crank levers "BC," to the connecting rods "BB" and the rods "RR" by means of rocker plate "RP" to the two winding arms "WA" which are provided with ratchet dogs on their inner sides which actuate the ratchet wheel and wind the springs. This operation imparts a reciprocating motion of the rod "AA," which is fastened to the right winding arm "WA" and connected by friction clutch lever "FC" to latch lever "V," thus releasing the "RL" lever, which moves back to normal by means of its counterweight, which locks the escapement wheel and stops the motor.

Provision is made to prevent over-winding; as the motor is always nearly or entirely wound, and when once fully wound, it will deliver about 20,000 strokes on the bell and will run continuously for one hour and forty minutes.

The process of winding is as follows:

As the motor springs are wound up, they gradually overcome the counteraction of the springs "SA," which causes the winding arms "WA" to sag down about ¾ in. so that the shoulders on the lower ends of the winding rods "RR" cannot be engaged by the reciprocating motion of the rocker winding plate "RP." When the motor springs commence to unwind, the springs "SA" lift the winding arms "WA" which raises the winding rods "RR" so that the shoulders on the lower ends of these rods are again brought in contact with the rocker winding plate "RP" which allows the motor springs again to wind when a train passes over the winding lever.

A small dial with pointer is shown on the face of the motor. This indicates to the signal maintainer the amount of potential energy stored up ready for service.

Names of Parts, Hoeschen Bell; Fig. 2241.

AA *Stopping Rod*
FC *Friction Clutch Lever*
L *Releasing Clutch Lever*
MM *Releasing Magnets*
N *Armature*
NN *Pointed Armature*
R *Rocker*
RL *Releasing Lever for Motor*
RP *Rocker Plate*
SA *Springs*
V *Latch Lever*
WA *Winding Arms (Right and Left)*
XX *Sliding Bar (for Raising Lever* **V**)

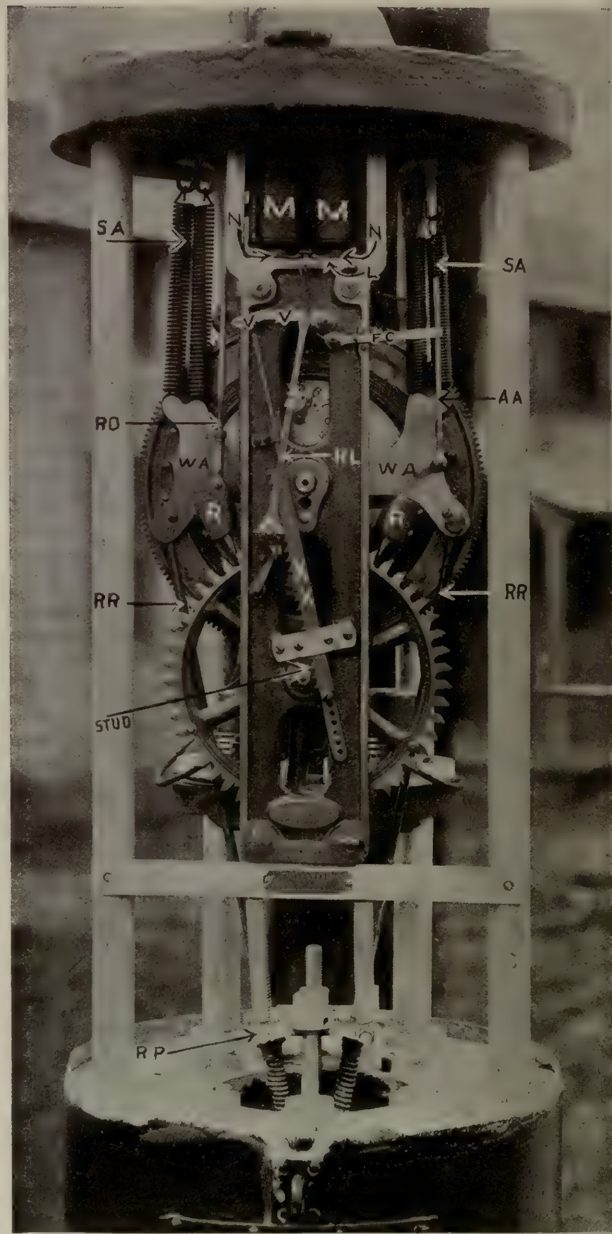


Fig. 2241. Details of Bell Mechanism. Hoeschen Manufacturing Company.

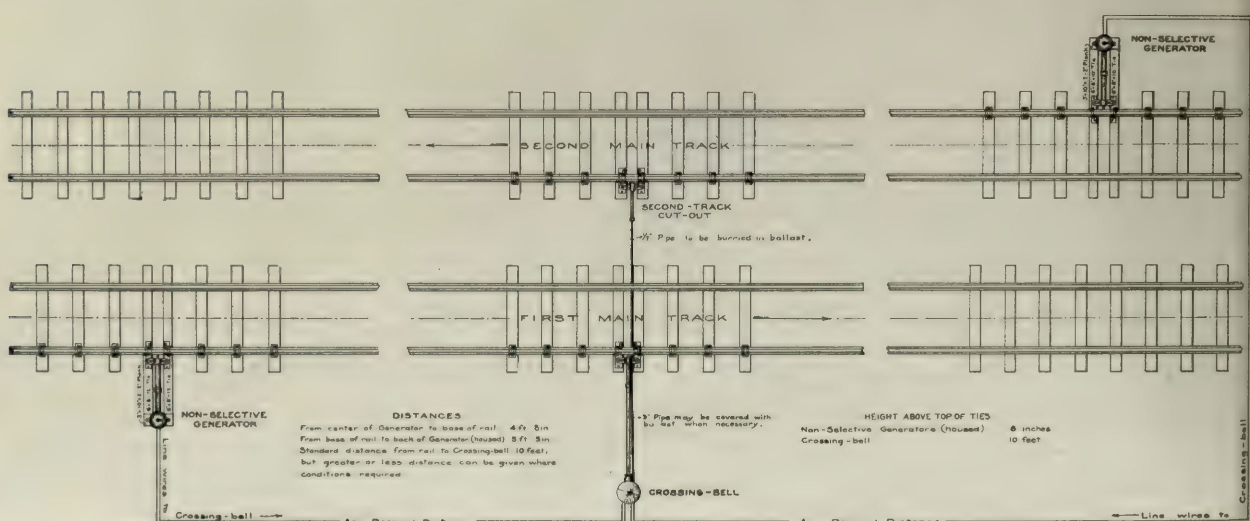


Fig. 2242. Arrangements of Crossing Bell for Double Track. Non-Selective Generators Used. Hoeschen Manufacturing Company.

ACCESSORIES

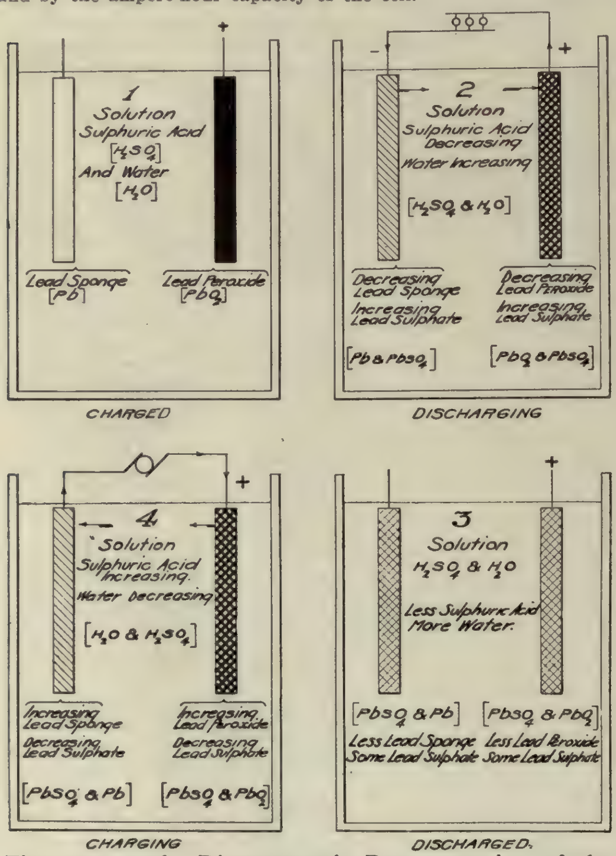
Pages 326-518 Figures 2243-3899

BATTERIES

STORAGE BATTERIES

Storage batteries are divided into two general classes; lead-sulphuric acid and two-metal batteries. The lead-sulphuric acid class has electrodes of peroxide of lead and finely divided metallic lead both on lead supports in an electrolyte of dilute sulphuric acid. It includes the Plante and Pasted (Faure) types. To the Plante type belong all those lead batteries whose active material is obtained by means of chemical or electro-chemical corrosion of the lead support, and whose electrolyte is a solution of sulphuric acid and water. To the Pasted type belong those batteries in which the active material consists of paste made of lead oxides applied to a grid. There are also various combinations and modifications of the above two types. The two-metal class of storage battery makes use of two dissimilar metals, as electrodes with an acid or alkaline electrolyte depending upon the particular type. The metal may be either in a highly divided state, an oxide or a salt.

Each cell of a lead-sulphuric acid battery has an electromotive force on discharge of approximately two volts, and an ampere hour capacity depending upon the number and size of plates. The energy capacity of the battery in watt-hours is approximately the number of cells in series multiplied by two, and by the ampere-hour capacity of the cell.



Figs. 2243-2246. Diagrammatic Representation of the Changes in a Lead-Sulphuric Acid Storage Battery During Charge and Discharge.

A lead storage cell consists essentially of an element comprising positive and negative plates placed alternately but grouped and connected respectively to a positive and a negative terminal, a dilute solution of sulphuric acid and water as an electrolyte, a containing jar and plate separators.

The changes taking place during discharge and charge are shown in Figs. 2243-2246, where the essential active elements are represented diagramatically.

In the charged battery, Fig. 2243, peroxide of lead (PbO_2) supported on a lead conducting frame is the positive electrode, sponge lead (Pb) supported on a similar frame is the negative electrode, and a mixture of sulphuric acid (H_2SO_4) and water (H_2O) is the electrolyte. In Fig. 2246 the external circuit has been completed and current is flowing from the positive plate through the external circuit into the negative plate through the solution back to the positive plate.

The lead peroxide of the positive plate is giving up its oxygen and by combination with the dilute sulphuric acid is being converted into lead sulphate. The lead of the negative plate is also combining with the dilute sulphuric acid and is being converted into lead sulphate, while water is being formed by the union of the oxygen liberated from the positive plate with the hydrogen liberated from the sulphuric acid. This chemical action continues until the sulphate formed on both plates reduces the activity of the remaining material (Fig. 2246).

In Fig. 2243 the battery is being charged. The positive and negative terminals of a generator are connected respectively to the positive and negative terminals of the battery. Current flows from the generator into the positive plate, through the solution to the negative plate back to the generator. Here the action which takes place is the reverse of discharging. Lead sulphate from both plates unites with the hydrogen of the water to form sulphuric acid, leaving finely divided metallic lead (lead sponge) at the negative plate, and at the positive plate lead combined with the oxygen liberated from the water forming lead peroxide. Thus at the end of the charge the battery is practically in the same state as at the beginning of discharge.

The above explanation of the action in a lead storage battery is known as the sulphation theory, and is now generally held to be correct. It may be expressed by the equation:

$$Pb + PbO_2 + 2H_2SO_4 = 2PbSO_4 + 2H_2O.$$

Reading from left to right this equation represents discharging and reading from right to left, charging.

Storage batteries are coming into increasing use for electric power interlocking plants, for operating drawbridges, power operated signals, track circuits, signal lighting, relays, indicators, bells and electric locks. In portable form they may be transported on cars to and from the charging station and the point where they are used for supplying current. In the stationary form for automatic signals, two sets of batteries are installed at each point and one charged while the other is discharged. To do this a line wire is run from the batteries to the power house and alternately connected to the two sets of batteries, one set being charged in series while the other set is connected to the signal apparatus. An attendant goes over the line and throws the change-over switch whenever either set of battery is to be charged.

INSTALLATION AND OPERATION OF STORAGE BATTERIES IN SIGNAL SERVICE.

The following instructions for installing, operating and caring for storage batteries were included in the report of the Special Committee on Storage Battery presented at the 1908 convention of the Railway Signal Association.

Storage batteries are used in connection with interlocking and block signals.

In interlocking plants the batteries are permanently located at the working points and charged from a central source of power.

In automatic work, batteries are used in three ways:

(1) Battery permanently located at working point and charged from transmission line.

(2) Battery permanently located at working point and charged from primary cells.

(3) Battery located at working point on discharge only—and removed to power source for recharge.

The batteries for interlocking plants, and applications 1 and 2 for block signals are never moved and are termed "stationary batteries."

The batteries for class 3 in block signals require a battery which can be readily handled and moved from place to place and therefore are termed "portable batteries."

Installation of Stationary Batteries.

The battery should be in a space by itself as the acid fumes given off during the charge are of corrosive nature. This space should be well ventilated, well lighted, and as dry as possible. If the space is specially constructed, it should contain no metal work other than lead. If this is not possible, then such metal parts should be protected by at least two coats of acid-proof paint. The floors of a large battery room should be preferably of vitrified brick, jointed with pitch.

The batteries should be placed in rooms of uniform temperature, preferably 70 deg. F. Low temperature does not injure a battery, but lowers its capacity approximately one-half per cent. per degree. Excessively high temperatures shorten the life of the plates.

If the batteries are in glass jars and not of the two-plate type, the following directions should be observed in installing.

Batteries up to 400 a. h. capacity shall be placed in glass jars. All batteries shall be for an eight-hour rate of discharge at 70 deg. F.

For a battery of a greater capacity than 400 a. h., wooden tanks shall be required and should be covered by special specifications.

In batteries of a large number of cells, such as in interlocking plants, substantial wood racks should be provided to support the cells. These racks should preferably be made of long leaf yellow pine with non-corrosive fastenings, and thoroughly protected by at least two coats of acid-proof paint. The cells should be arranged transversely, and the lay-out of cells should be such that each cell is accessible for inspection and sufficient head room over each cell to remove the element without moving the jar.

Each jar is set in a tray which has been evenly filled with fine dry bar sand, the trays resting on suitable insulators.

When placing the positive and negative groups into the jars, see that the direction of the lugs is relatively the same in each case, so that a positive lug of one cell adjoins and is connected to a negative lug of the next cell, and so on throughout the battery; this insures the proper polarity throughout the battery, bringing a positive lug at one free end and a negative at the other.

Before bolting the battery lugs together, they should be well scraped at the point of contact to insure good conductivity and low resistance of the circuit. The connector studs should be covered with vaseline before screwing up, and the entire connections covered with vaseline or suitable paint.

Fig. 2247. Storage Battery Installation. Chicago Terminal. Chicago & North-Western.

Before putting the electrolyte into the cells, the circuits connecting the battery with the charging source must be completed, care being taken to have the positive pole of the charging source connected with the positive end of the battery, and so with the negative poles. The electrolyte should cover the top of plates by one-half inch.

Electrolyte. The electrolyte shall be of a quality and specific gravity approved by the battery manufacturer.

If it is not practicable to obtain approved electrolyte, tests for the purity of the supply obtained should be made before it is used. Specifications for tests will be found under heading, "Specifications for Tests for New Electrolyte."

Initial Charge. The initial charge should follow the manufacturer's instructions. The charge should be started promptly as soon as all the cells are filled with electrolyte, and all connections made, usually at the normal rate, and continued at the same rate until both the specific gravity and voltage show no rise over a period of 10 hours, and gas is being freely given off from all the plates. The positive plates will gas sometimes before the negatives. Generally, to meet these conditions, from 45 to 55 hours' continuous charging at the normal rate will be required; and if the rate is less, the time required will be proportionately increased. In case the charge is interrupted, particularly during its earlier stages, or if it is not started as soon as the electrolyte is in the cells, the total charge required (in ampere hours) will be greater than if the charge is continuous and is started at once.

As a guide in following the progress of the charge, readings should be regularly taken and recorded. The gassing should also be watched, and if any cells are not gassing as much as the surrounding cells, they should be carefully examined and the cause of the trouble removed. The temperature of the electrolyte should be closely watched, and if it approaches 100 deg. F., the charging rate must be reduced or the charge temporarily stopped until the temperature lowers.

The specific gravity will fall after the electrolyte is added to the cells, and will then gradually rise as the charge progresses, until it is up to 1,210 or thereabouts.

The voltage of each cell at the end of the charge will have risen to its maximum, and usually will be between 2.50 and 2.70 volts, and for this reason a fixed or definite voltage should not be aimed for.

If the specific gravity of any of the cells at the completion of the charge is below 1205, or above 1215, allowance being made for the temperature correction, it should be adjusted to within these limits, by removing and adding electrolyte if specific gravity is low, and adding pure water if the specific gravity is high, to again bring the surface at the proper height above the top of the plates.

It is of the utmost importance that the initial charge be complete in every respect.

Note.—In the case of batteries charging from primary cells, if possible, the initial charge should be given at a place where direct current is available of sufficient voltage to carry through the charge at the normal rate (see general instructions), the cells being then transferred to their permanent position.

Two-Plate Cells. The general method of installation is the same as the above, with the following exceptions:

Each cell contains one positive and one negative, the positive of one jar being solidly connected by a lead strap to the negative plate of the adjoining jar, and consequently no connectors are required. At the ends of each row there is one free positive plate and one free negative plate, respectively, which constitute the positive and negative terminals of that row. Connections to these terminals are made with bolt connectors.

For the installation of very large batteries, where tanks are used, it is customary to support the tanks on a double tier of glass insulators. The plates are shipped separately and assembled one at a time in the tank and burned solidly to a heavy lead bus bar by means of a hydrogen flame. It is recommended, when installations of this kind are required, that the battery manufacturers install the battery in accordance with their standard practice.

Installation of Portable Batteries.

Initial Charge. The initial charge should follow the manufacturer's instructions. If, as is the usual practice, the battery is shipped with the electrolyte (solution) in the cells, immediately upon receipt remove the vent plugs from each cell, and *if the electrolyte does not cover the plates* add sufficient pure water until the plates are covered ½ inch. Although the battery is fully charged before shipment, it is advisable to give it a five-hour charge at the normal rate, as given on the name plate.

If, however, the battery is shipped "dry" or without the electrolyte in the cells, and equipped with rubber separators, it should be usually put in service as follows: Fill the cells slowly with electrolyte of 1170 specific gravity (see note) until the plates are covered one-half (½) inch, and then immediately start the charge at one-half the normal rate, and continue until the voltage of each cell has ceased to rise and the cells have been gassing freely over a period of 10 hours, and there is no further rise in the specific gravity over the same period. About 70 hours at one-half the normal charge rate will be required to complete the charge; if the rate is less than this, the time required will be proportionately increased. If the temperature of the electrolyte rises to 110 deg. F. during the charge, the current should be reduced or stopped until it lowers. After the completion of the charge, adjust the specific gravity to between 1275 and 1300, with the electrolyte at the proper height (one-half inch above the plates).

Note.—If the battery is assembled on the ground, and wood separators are used, then the electrolyte used for filling should be of 1210 sp. gr. If rubber separators are used, the electrolyte used for filling should be 1710 sp. gr.

Routine Instructions for the Operation and Care of Storage Batteries in Interlocking Plants.

Pilot Cell. In each battery, select a readily accessible cell, to be used in following the daily operation of the battery, by taking specific gravity readings of the electrolyte, as given below. Keep the level of the electrolyte of this cell at a fixed height, one-half inch above the top of the plates, by adding a small quantity of pure water each day; *this is extremely important.*

Charging. As a general rule, do not charge until the gravity of the pilot cell has fallen at least 10 points (.010 sp. gr.) below the preceding overcharge maximum (see "Overcharge" below), the battery being then about one-third discharged.

In any case, charge as soon as possible after reaching either of the limits given below under "discharging," or if for any reason a heavy discharge is expected.

Regular Charge. Charge at the normal rate of......amperes, or as near as possible, and continue until the gravity of the pilot cell has risen to three points below the maximum reached on the preceding overcharge, *when the charge should be stopped;* for example, if the maximum gravity on the overcharge is 1207, the gravity reached on regular charge should be 1204. The cells should be all gassing moderately.

Overcharge. Once every two weeks, on..............prolong the regular charge until 15-minute readings of the gravity of the pilot cell and of the battery voltage, taken from the time the cells begin to gas, show no rise on five successive readings, thus having been at a maximum for one hour.

Note.—When the above method of overcharge is not practicable, the overcharge may be given every sixth charge, provided the battery receives an overcharge at least once every month. If ~~in following this method~~, i. e., where the overcharge is given at intervals longer than two weeks and not less frequently than once a month, the regular charge should be prolonged until one-half hour readings of the gravity of the pilot cell and of the battery voltage, taken from the time the cells begin to gas, show no rise on seven successive readings, thus having been at the maximum for three hours. The cells should all be gassing freely. The overcharge should be given whether the battery has been in regular use or not.

Charging in Series. If two or more batteries are charged together in series, care should be taken that each battery is cut out at the proper time; in other words, if one of the batteries discharges less than the other, it should not receive as much charge.

Discharging. Never allow the gravity of the pilot cell to fall more than about 30 points below the preceding overcharge maximum. As a rule, do not allow gravity to fall more than 20 points.

Never allow the voltage to go below 1.85 *volts per cell* when discharging at the normal rate (......amperes). If the rate of discharge is less than the normal rate, the voltage should not be allowed to go so low.

Limiting voltage.........cells.........volts.

Never allow the battery to stand in a *completely discharged* condition.

Readings. Read and record the gravity of the pilot cell and battery voltage just before the start and the end of every charge, together with the temperature of the electrolyte.

To properly compare the gravity readings, they should be corrected to standard temperature, 70 deg. F., as follows: Add one point (.001) for every three degrees above 70 deg. F., and subtract one point (.001) for every three degrees below 70 deg. F.

Once every two weeks, after the end of the charge preceding the overcharge, read and record the gravity of each cell in the battery.

Inspection. Carefully inspect each cell on the day before the overcharge, using a lamp on an extension cord for the purpose. Examine between the plates and hanging lugs to make sure that they are not touching, and also make a careful note of any peculiarity in color, etc., of the plates.

Use a strip of wood or hard rubber in removing short circuits. *Never use metal.*

Towards the end of the charge preceding the overcharge, note any irregularity of gassing among the cells; any which are slow in gassing should be investigated.

Indications of Trouble. Falling off in specific gravity or voltage relative to the rest of the cells.

Lack of or slower gassing on overcharge, as compared with surrounding cells.

Color of plates markedly lighter or darker than in surrounding cells, except that sides of plates facing glass may vary considerably.

In case of any of the above symptoms being found, examine carefully for cause, and remove at once.

Report trouble of any description at once to................

Broken Jars. If a jar should break, and there is no other to take its place, so that the plates will have to remain out of service for some time, keep the negatives wet in a tub of water and allow the positives to dry. Connect into circuit again just before a charge, so that the plates will receive the benefit of the charge.

Other Important Points. The plates must always be kept covered with electrolyte. Use only pure water, preferably distilled, to replace evaporation.

Never add electrolyte except under the conditions explained in the general instructions.

Never allow the sediment to get up to the bottom of the plates; remove when the clearance has reached one-half inch.

Ventilate the room freely, especially when charging.

Never bring an exposed flame near the battery when charging.

Never allow metals or impurities of any kind to get into the cells; if such has happened, remove at once, wash the plates and replace the electrolyte.

Fill out the report sheets regularly.

Read the general instructions carefully.

Routine Instructions for the Operation and Care of Storage Batteries in Block Signal Service. Central Charging Plant.

Charging. When to charge: Unnecessarily frequent charging should be avoided, but to insure a reserve in case of emergency it is advisable not to take out on discharge more than one-third capacity, this being indicated by the fall of the specific gravity of the electrolyte. The fall in gravity is in proportion to the ampere hours discharged and for a discharge equal to one-third capacity in approximately 10 points (.010 specific gravity). How frequently each circuit or series of batteries should be charged will be governed by the battery in the circuit having the greatest average amount of discharge. Having determined which battery first shows a drop in gravity from full charge to the regular working limit (not exceeding 10 points) charge often enough to prevent the gravity of the battery falling below this limit.

Regular Charge. Charge at an average rate of........amperes for..........hours (this being the time required to bring the battery having the greatest discharge up to full charge, as indicated by the specific gravity and voltage ceasing to rise).

Overcharge. Once every two weeks prolong the regular charge for three hours.

Discharging. As a general rule, do not continue the discharge after the gravity of the battery receiving the most discharge has fallen more than 10 points from maximum. Never, however, except in case of emergency, allow the gravity to fall more than 30 points from maximum, or the voltage below 1.85 volts per cell when discharging at the normal rate (.......... amperes). If the rate of discharge is less than the normal rate, the voltage should not be allowed to go so low.

Readings. Once a month, on the day before the overcharge, read and record the gravity of each cell of each battery on the circuit, together with the average temperature of the electrolyte.

To properly compare the gravity readings, they should be corrected to standard temperature, 70 deg. F., as follows: Add one point (.001) for every three degrees above 70 deg. F., and subtract one point (.001) for every three degrees below 70 deg. F.

Inspection. Carefully inspect each cell, once a month, on the day before the overcharge. Examine between the plates and hanging lugs to make sure that they are not touching, and also make a careful note of any peculiarity in color, etc., of the plates. Always use a strip of wood or hard rubber in removing short circuits. *Never use metal.*

In case a battery or individual cell is found to be in poor condition, due to overdischarge, short circuits, impurity in the electrolyte or sediment touching the plates, it may be well or advisable to remove it to the charging plant for treatment, first substituting in its place a fully charged battery or cell, or else a portable set kept for the purpose (for treatment of low cells, see "General Instructions").

The instructions under the headings "Indications of Trouble," "Broken Jars," and "Other Important Points" are the same as those for Storage Batteries in Interlocking Plants, given on this page.

Routine Instructions for the Operation and Care of Batteries in Signal Service. Charging from Primary Cell.

Operation. For regular operation, sufficient primary cells (connected either in single series or multiple series) should be installed to maintain the storage cells at approximately a constant state of charge, as shown by the specific gravity of the electrolyte remaining at about the same point. If the gravity falls off, there is a lack of sufficient charge. The voltage per cell should average between 2.08 and 2.12 volts. A higher average than this shows that the battery is receiving too much charge, which is also indicated by a constant slight gassing; a lower average voltage indicates insufficient charge, resulting in the falling off in gravity referred to above.

The gravity of the cells operating as above, in a fully charged state, should be between 1205 and 1215 at normal temperature (70 deg. F.) and with the electrolyte one-half inch above the plates. Should there be an unusual drop in the gravity, say from 10 to 15 points (.010 to .015 sp. gr.) below the normal, or of the voltage below 1.95 volts per cell, the cause should be investigated.

Readings. At intervals, not exceeding one month, read and record, on a suitable form, the gravity and voltage of each storage cell, together with the temperature of the electrolyte, and by means of a portable ammeter read and record the charging current delivered from the primary cells.

To properly compare the gravity readings, they should be

corrected to standard temperature (70 deg. F.), as follows: Add one point (.001) for every three degrees above 70 deg. F., and subtract one point (.001) for every three degrees below 70 deg. F.

Inspection. At the time the readings are taken, inspect each storage cell, examining between the plates and hanging lugs to make sure that they are not touching, and also make a careful note of any peculiarity in color, etc., of the plates.

Always use a strip of wood or hard rubber in removing short circuits. *Never use metal.*

See that the cell connections are clean and tight.

In case a battery or individual cell is found to be in poor condition, due to overdischarge, short circuits, impurities in the electrolyte, or sediment touching the plates, it will be advisable to remove it to some central point where it can be treated to better advantage, substituting in its place a fully charged battery or else a portable set kept for the purpose.

The instructions under the headings "Indications of Trouble," "Broken Jars" and "Other Important Points" are the same as those for storage batteries in interlocking plants, given on page 328.

Routine Instructions for the Operation and Care of Portable Storage Batteries in Signal Service.

When to Charge. Charge each battery frequently enough to keep the specific gravity of the electrolyte from falling more than 80 points (.080 sp. gr.) below what it read when fully charged, the battery then being about two-thirds discharged. For instance, if the gravity, when fully charged, is 1300, do not allow it to fall below 1220.

In any case, the battery should be charged once a month, whether it is in use or not. If the battery has been idle, it should be charged before putting into service again.

Charging. Remove the vent plugs before charging. Charge at the rate of .... amperes. After the cells begin to gas, read and record the gravity and voltage of each cell every two hours, continuing to charge until three of these readings are alike.

If the time for charging is limited, the charge may be started at .... amperes, reducing the rate to .... amperes when the cells begin to gas, continuing the charge until four readings of the gravity and voltage, taken every two hours, are alike.

The cells should all be gassing freely at the end of charge.

Do not allow the temperature of the electrolyte to exceed 100 deg. F., while charging. If it tends to do so, reduce the charging rate or discontinue charging until it lowers.

Discharging. Never, except in case of emergency, allow the gravity to fall more than 80 points below what it read when last charged.

Readings. Record, on a suitable form, the specific gravity of each battery before starting the charge and at its completion, including, with the latter, voltage readings taken with the charging current flowing.

Electrolyte. Replacing evaporation. Keep the plates well covered with electrolyte and use only pure water to replace evaporation. Never use electrolyte for this purpose.

Adjusting Specific Gravity. The gravity of the electrolyte should, with the cells fully charged, be between 1270 and 1300, and unless actually lost through spilling or a leaky jar, it should not need frequent adjustment. If, at the end of charge, the gravity does not rise to its normal value, the battery should be carefully inspected for short circuits or other troubles and if any are found they should be removed and the charge continued until gravity ceases to rise. If no short circuits or other troubles are found, the gravity should be brought up to 1300 by replacing some of the electrolyte with electrolyte having a higher gravity. Should it read above 1300, it should be reduced by taking out a little electrolyte and replacing with pure water. To accomplish the above result it will generally be found more convenient to pour out all the old electrolyte and replace at once with new of the proper gravity.

General Care. After a battery has been charged, the outside of the case and tops of jars should be carefully cleaned. The connectors should be taken apart and washed in a solution of bi-carbonate of soda and water and rinsed with water and, when dry, well oiled.

The case should also be well oiled before sending the battery out. Oil should never be allowed to come in contact with soft rubber.

Once, each year, each battery should be taken apart, the sediment removed from the bottom of the jar, and the plates and separators lightly washed before replacing. Any broken or damaged parts should be renewed. Do not allow the plates to dry. The old electrolyte can be used again, adjusting it to the proper gravity at the completion of the charge, following the cleaning. Every second cleaning, it is advisable to use new electrolyte.

Indications of Trouble. Falling off in specific gravity or voltage relative to the rest of the cells.

Lack of or slower gassing on overcharge, as compared with surrounding cells.

Color of plates markedly lighter or darker than in surrounding cells, except that sides of plates facing glass may vary considerably.

In case of any of the above symptoms being found, examine carefully for cause, and remove at once.

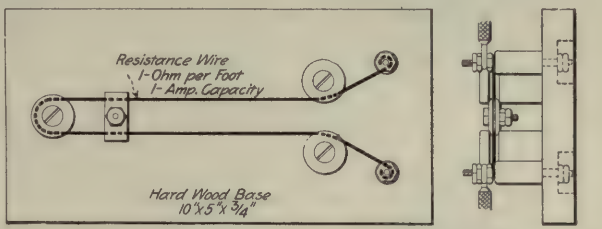
Important Points. Always fully charge.

The plates must always be kept covered with electrolyte.

Use only pure water, preferably distilled, to replace evaporation.

Never add electrolyte except under the conditions explained above.

Never allow the sediment to get up to the bottom of the plates.



Figs. 2248-2249. Adjustable Resistance for Storage Battery When Used on Track Circuits. Chicago, Milwaukee & St. Paul.

Ventilate the room freely when charging.

Never bring an exposed flame near the batteries when charging.

Never allow metals or impurities of any kind to get into the cells; if such has happened, remove at once, wash the plates and replace the electrolyte.

Fill out the record sheets regularly.

Specifications and Tests for New Electrolyte.

Color. The sample should be absolutely clear and colorless, showing no dark color, due to organic matter. A small amount of lead sulphate, sometimes present, which shows as a white sediment, will do no harm.

Odor. Shake up a closed flask or bottle partially filled with the electrolyte, then uncork and note whether there is any odor. Sometimes sulphurous or nitric acid can be detected in this manner, and the further testing be very much shortened.

Chlorine. To a sample of the electrolyte in a test tube add a few drops of nitric acid, then a little silver nitrate solution. Note the appearance cold, then boil. The sample should remain perfectly clear when cold, and show only a slight, if any, turbidity on boiling.

Iron. To a few cc. of the sample in a test tube add weak potassium permanganate solution, drop by drop, until a faint pink color is permanent. Then add a little ammonium (or potassium sulphocyanate solution), when the presence of iron will be indicated by a red color. It is almost impossible to obtain acid which will not show a faint color by this test, as it is very delicate, but if the color is at all deep the acid should be rejected or else submitted for a quantitative analysis.

Oxides of Nitrogen. Take about five cc. of diphenylamin solution (½ gram to 100 cc. c. p. sulphuric acid, 1.84 sp. gr., and 20 cc. distilled water) in a test tube, and carefully pour in about an equal volume of the electrolyte to be tested. The presence of oxides of nitrogen, or nitric acid, is shown by a deep blue color at the intersection of the two liquids.

Heavy Metals (Platinum, Copper, etc.), Arsenic, Selenium and Sulphurous Acid. Treat about 100 cc. with hyrdogen sulphide until thoroughly saturated. The solution should remain perfectly clear, and show no color or precipitate. A negative result shows absence of heavy metals, also arsenic, selenium and sulphurous acid. A very slight separation of sulphur may be neglected, but if the solution becomes quite turbid, sulphurous acid should be tested for as follows: Place some of the electrolyte in a small narrow-necked flask and add some finely divided pure zinc. Test the gas evolved with filter paper saturated with lead acetate solution. If the paper turns brown or black, sulphurous acid is present.

Note.—It should be understood that these tests are for new electrolyte which has not previously been used in a battery. If the results obtained from any of the several tests are such as to allow of any uncertainty regarding the suitability of the electrolyte, a sample (at least eight ounces) should be submitted to the battery manufacturer; likewise any samples of old electrolyte from cells in which the presence of impurities is suspected.

Type "BT."

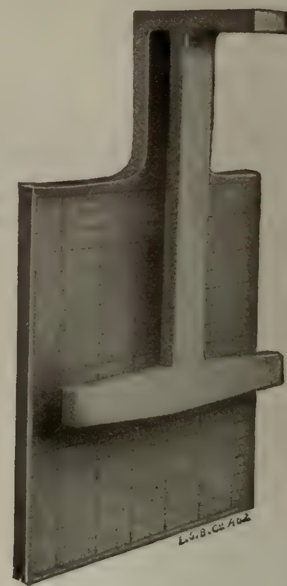
Type "PT."

Type "ET."

Figs. 2250-2252. Three Types of Two-Plate Cells. "Chloride Accumulator." Electric Storage Battery Company.

Positive Terminal Plate.

Couple.



Negative Terminal Plate.

Figs. 2253-2255. Plates of Type "CT" Cell. Electric Storage Battery Company.

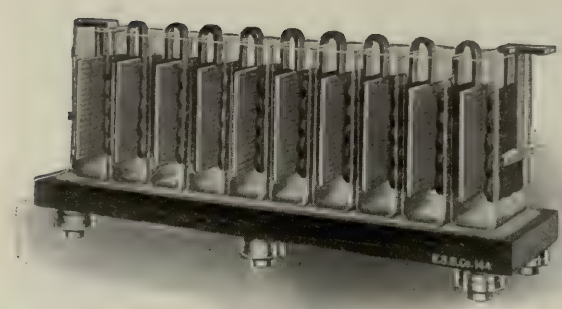


Fig. 2256. Two-Plate Type Stationary Battery in Glass Jars for Operating Automatic Signals, Low Voltage Control Circuits, Bells, etc.—Type "CT" Cells on Sand Tray "Chloride Accumulator."—

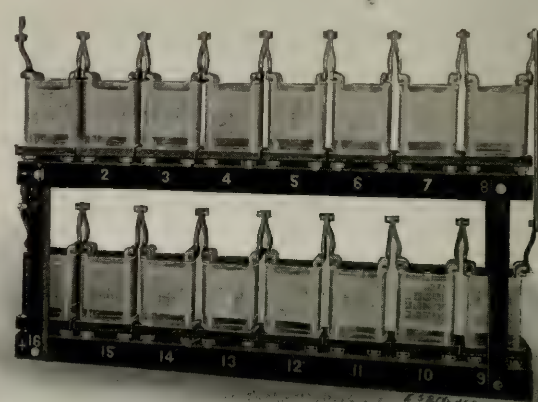


Fig. 2257. Multiple-Plate Type Stationary Battery for Operating Electric Power Interlocking Plants, Automatic Signals and Track Circuits, Low Voltage Control, Electric Locks, etc.—16 Cells on Rack. "Chloride Accumulator."

Figs. 2250-2257. Cells and Plates. Electric Storage Battery Company.

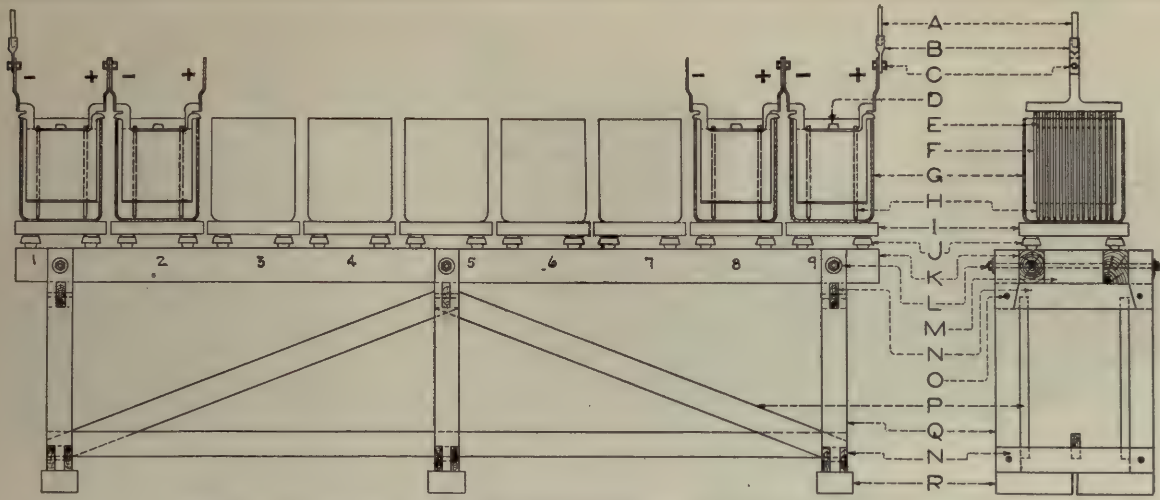


Fig. 2258. Diagram of Battery Parts. Electric Storage Battery Company.

Names of Parts, Storage Battery. Fig. 2258.

A *Copper Conductor*
B *Lead Terminal Lug*
C *Lead-covered Bolt Conductor*
D *Glass Hold-down*
E *Positive Plate*
F *Negative Plate*
G *Glass Jar*
H *Wood Separator Dowel*
I *Sand Tray*
J *Glass Insulator*
K *Rail*
L *Iron Bolt*
M *Spacing Block*
N *Cross Tie*
O *Dowel Pin*
P *Brace*
Q *Upright*
R *Vitrified Brick*
\+ *Positive Lug*
— *Negative Lug*

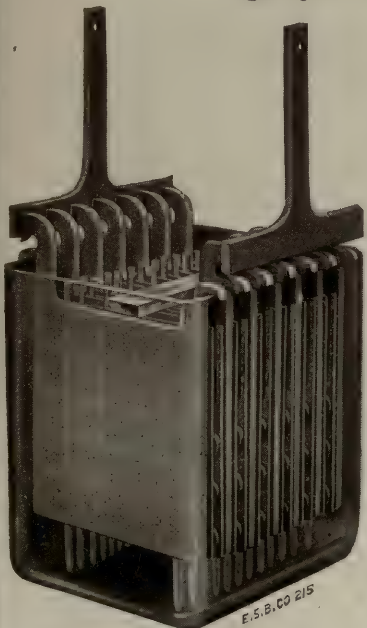


Fig. 2259. Type "E" 13, in Glass Jar. "Chloride Accumulator."

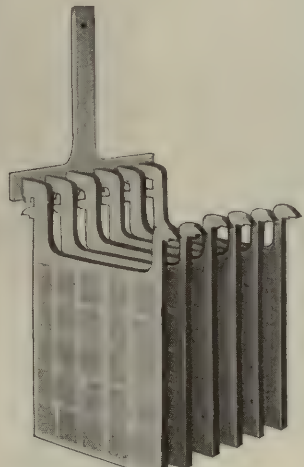


Fig. 2261. Group of Negative Plates. Type "E" 11. "Chloride Accumulator."

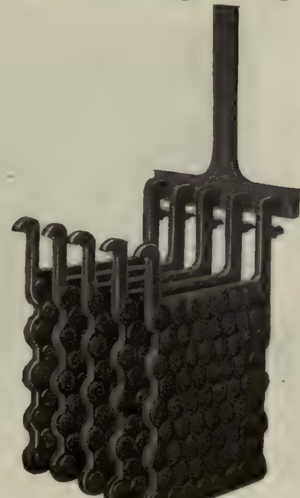


Fig. 2262. Group of Positive Plates. Type "E" 11. "Chloride Accumulator."

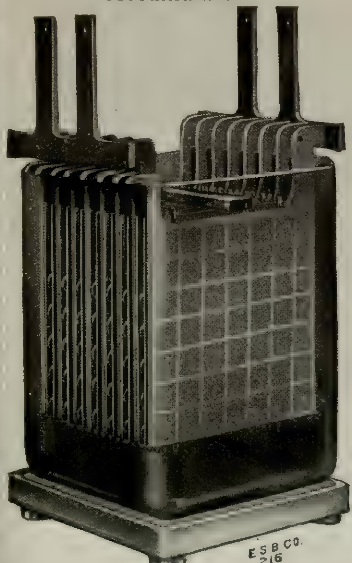
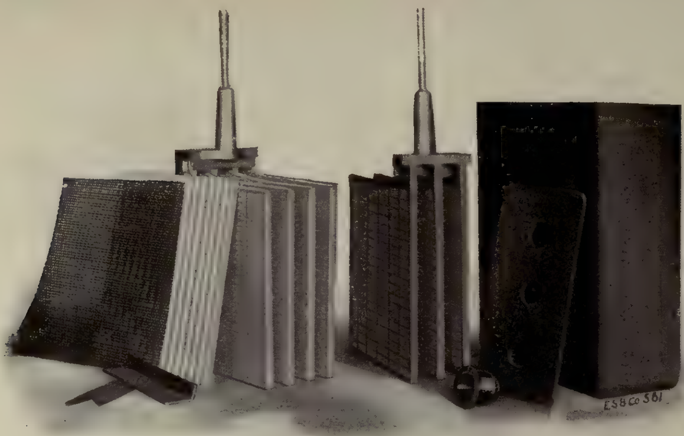


Fig. 2260. Type "F" 15, in Style A Glass Jar on Glass Tray. "Chloride Accumulator."

Fig. 2263. Group of Negative Plates. Type "E" 11 "Tudor Accumulator."

Fig. 2264. Group of Positive Plates. Type "E" 11 "Tudor Accumulator."

Figs. 2258-2264. Cells and Plates. Electric Storage Battery Company.



Figs. 2265-2268. "Exide" Dismantled Signal Cell. From Left to Right—Hard rubber hold downs for separators, perforated sheet rubber separators, wood separator, negative group, positive group, vent plug, cover, rubber jar.

Fig. 2269. "Exide" Portable Signal Cell. Harriman Lines.

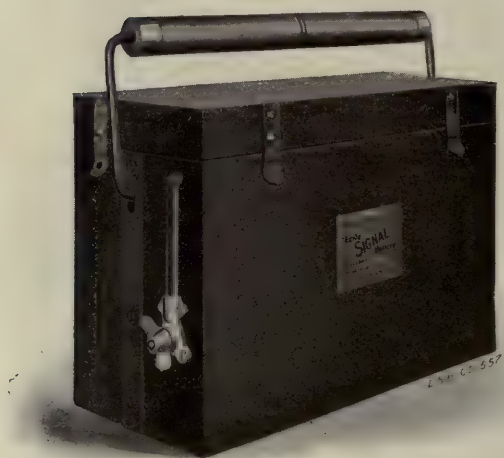


Fig. 2270. "Exide" Portable Signal Battery Type 4-SS-9. Burned Connections Between Cells, Sealed Top, Wooden Case, Cover in Position.

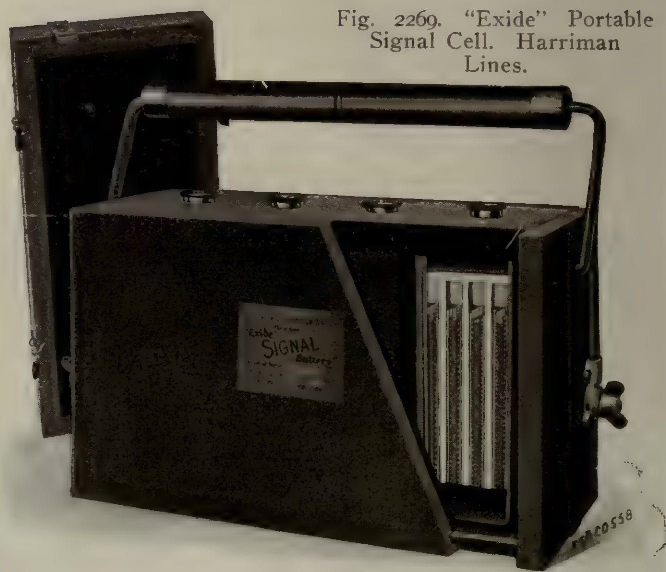


Fig. 2271. "Exide" Portable Signal Battery Type 4-SS-9. Burned Connections Between Cells, Sealed Top, Side Cut Away to Show Construction.

Fig. 2272. "Exide" Type SS7. Side Cut Away to Show Construction.

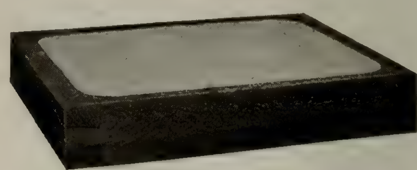


Fig. 2273. Wood Sand Tray for Glass Jar Cells.

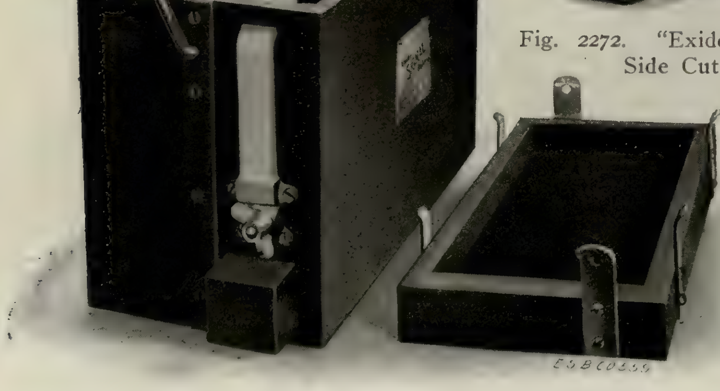



Fig. 2274. "Exide" Portable Signal Battery Type 4-SS-9. Bolted Connections Between Cells.

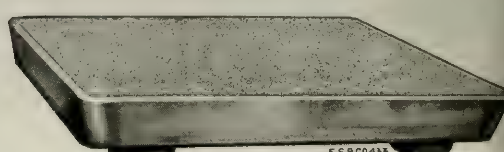


Fig. 2275. Type "E" Glass Sand Tray for Glass Jar Cells.

Figs. 2265-2275. Signal Cells. Electric Storage Battery Company.

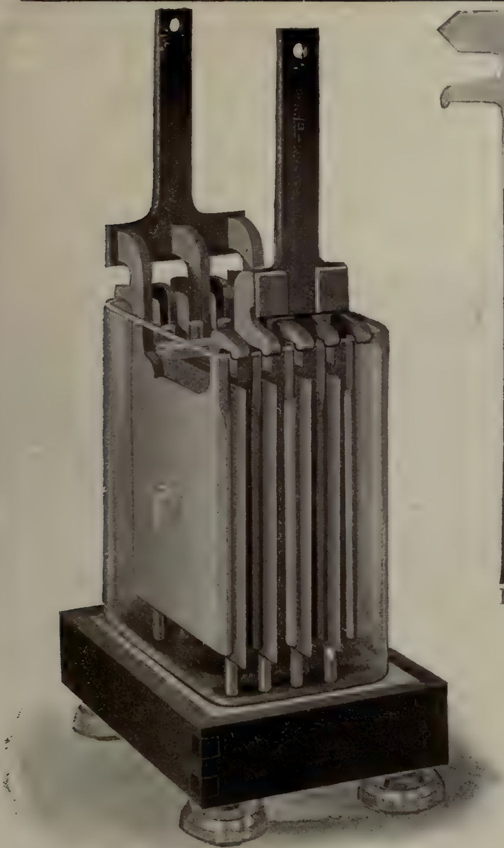


Fig. 2276. Type "DS-5" Storage Battery. Willard Storage Battery Company.

Fig. 2277. Positive Plate. Willard Storage Battery Company.

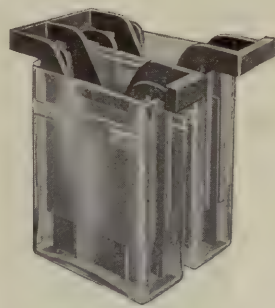


Fig. 2281. Type "W. S." Couples. Gould Storage Battery Company.

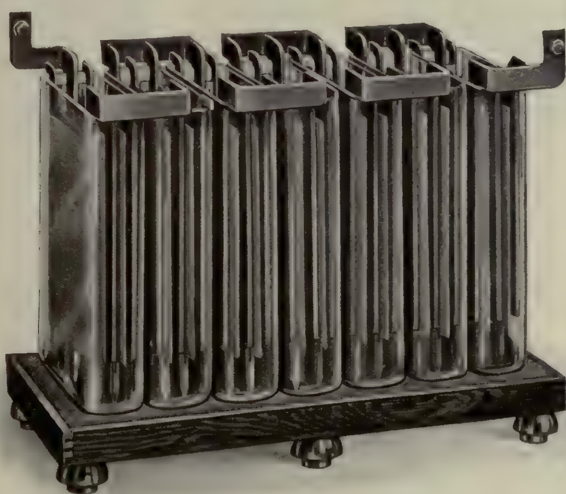


Fig. 2282. Type "C. Z." Cell Complete. Gould Storage Battery Company.

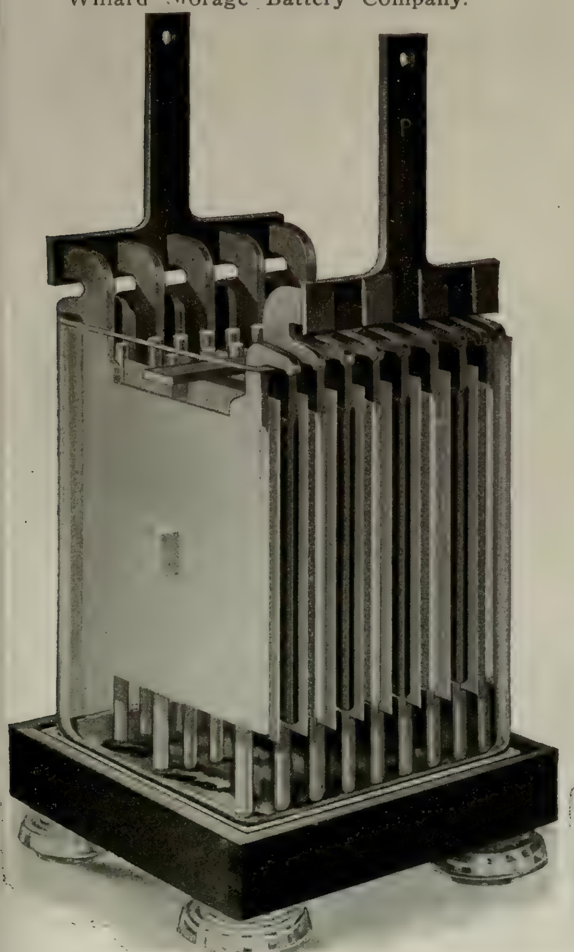


Fig. 2278. Type "E-9" Storage Battery. Willard Storage Battery Company.

Fig. 2279. Negative Group. Willard Standard Plates.

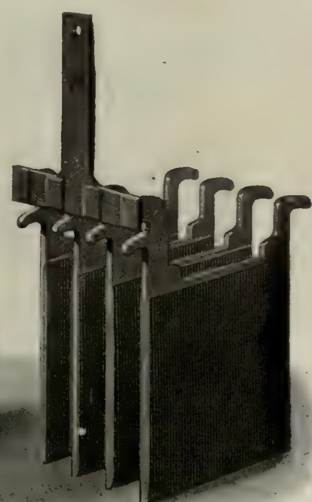
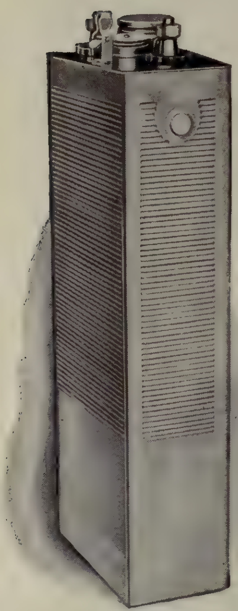


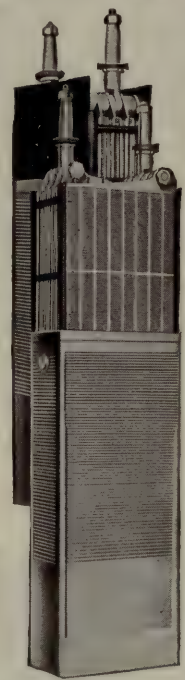
Fig. 2280. Positive Group. Willard Standard Plates.

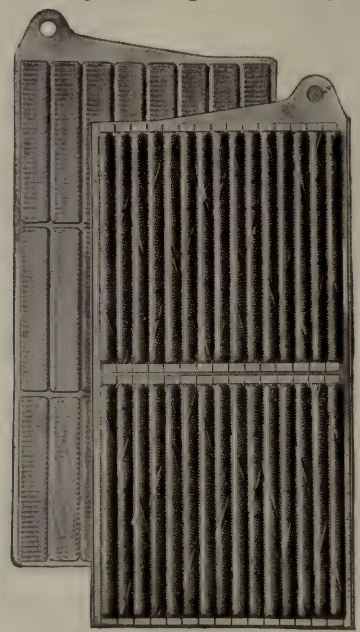
EDISON STORAGE BATTERY.

A cell is one complete unit of a storage battery, consisting of plates, electrolyte and steel container. The positive or nickel plate consists of one or more perforated steel tubes, heavily nickel plated, filled with alternate layers of nickel hydroxide and pure metallic nickel in exceedingly thin flakes.


Cell Completely Assembled.


Top View Complete Cell.


Positive and Negative Plates.

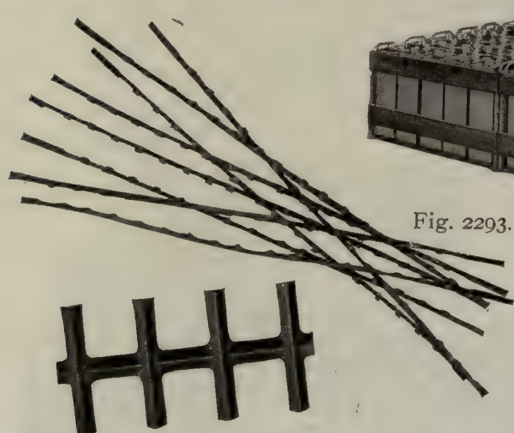

Construction of Positive and Negative Plates.


Complete Element with Insulators.

Figs. 2283-2290. Views of Type A-4 Cell. Edison Storage Battery Company.

The tube is drawn from a perforated ribbon of steel, nickel plated, and has a spiral lapped seam. This tube after being filled with active material is reinforced with eight steel bands, equi-distant apart. The tubes are held in perfect contact with a supporting frame made of cold rolled steel, nickel plated. The tubes are ¼ in. in diam. and 4¼ in. long. The positive plate is made in two standard sizes: Size "A" with 30 tubes in two rows, and size "B" with 15 tubes in one row.

The negative or iron plate consists of a grid of cold rolled steel, nickel plated, holding a number of rectangular pockets


Figs. 2291-2292. Vulcanized Rubber Insulation and Piece Used for Insulating Plates from Bottom of Container.

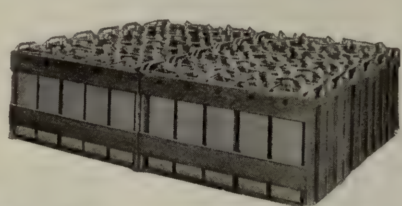


Fig. 2293. Edison Cells Assembled in Trays.


Figs. 2294 - 2295. Positive and Negative Plates "B-4" Cell.


Fig. 2296. Type "B-4" Cell Complete.

filled with powdered iron oxide. These pockets are made up of very finely perforated steel, nickel plated. After the pockets are filled they are inserted in the grid and subjected to great pressure between dies which corrugate the surface of pockets and force them into practically integral contact with the grid.

After the plates are assembled into a complete element, narrow strips of treated hard rubber are inserted between the plates, thereby separating and insulating them from each other. The side insulator is provided with grooves that take the edges of the plates, thereby separating the plates and insulating the complete element from the steel container. At the end of element, that is, between the outside negative plates and the container, are inserted smooth sheets of hard rubber. At the bottom the element rests upon a hard rubber rack or bridge less than one inch high, insulating the plates from bottom of container. In the Edison cell no active material is precipitated.

The jar or container is made throughout from cold rolled sheet steel of fine quality. The container is welded at the seams by the autogenous method, making leakage or breakage from severe vibration impossible. The cover is of the same quality sheet steel, is nickel plated, and has four mountings, two being pockets for containing stuffing boxes about the terminal posts. One of the other two is the separator, so called because it separates spray from the escaping gas while the battery is charging. The fourth mounting is an opening for filling the cell with electrolyte, and for the adding of distilled water to take the place of that which evaporates during the charge. This has a water and air tight cap, latched in place.

The electrolyte consists of a 21 per cent solution of potash in distilled water with a small per cent of lithia. The density of the electrolyte does not change on charge or discharge.

Nothing but clean distilled water should be used in refilling. A special filling apparatus automatically indicates when the solution is at required depth above plates.

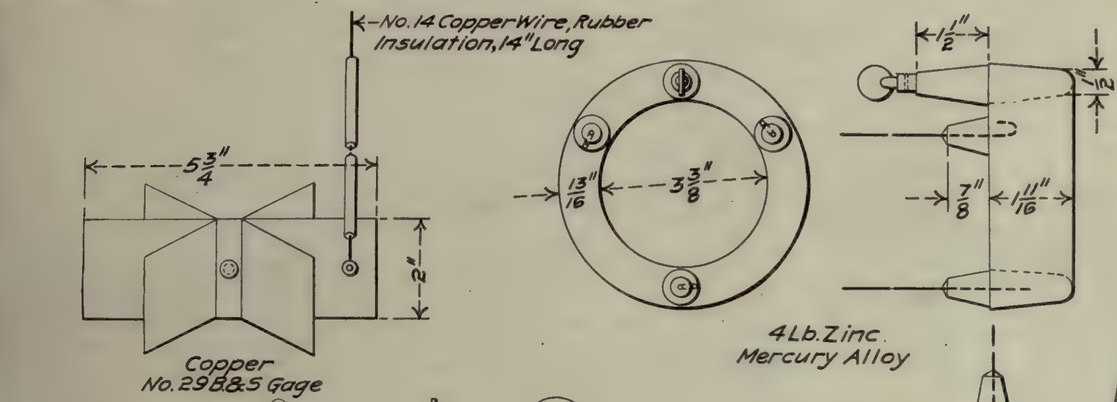
Every metal part that enters into the construction of the Edison cell is nickel plated. The process of nickeling is the simple one of electroplating, and an annealing process fuses the metals together, making them inseparable.

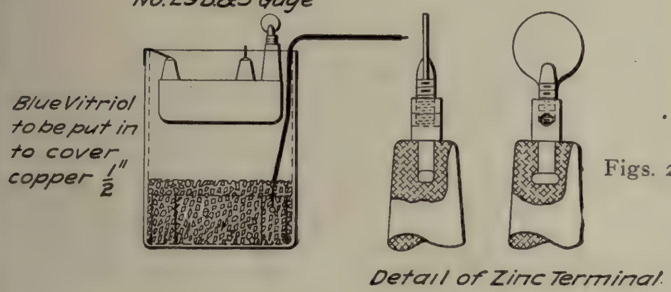
The voltage of the cell is 1.2 volts. In charging a voltage of 1.85 volts per cell should be provided. The capacity of the cell varies with the size and number of plates. The sizes in most common use are:

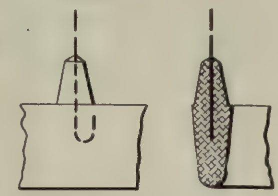
Size.	B-2	B-4	B-6	A-4	A-6	A-8	A-10	A-12
Nor. dis. rate, amp..	7.5	15	22.5	30	45	60	75	90
Ampere hours	40	80	120	150	225	300	375	450

PRIMARY BATTERIES.

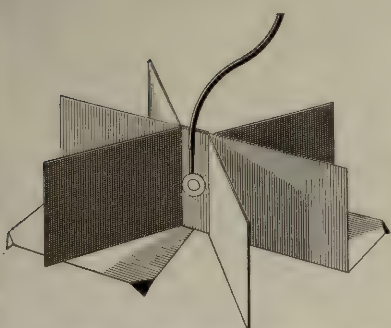
GRAVITY BATTERY.

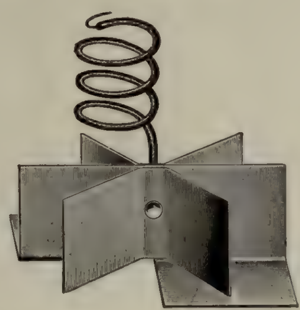






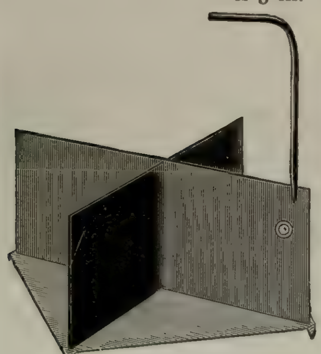
Figs. 2297-2302. Gravity Battery Details. New York Central & Hudson River.

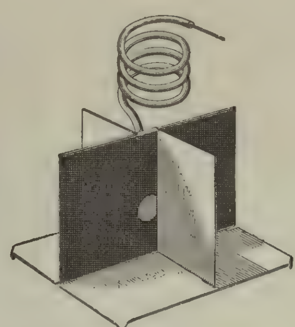


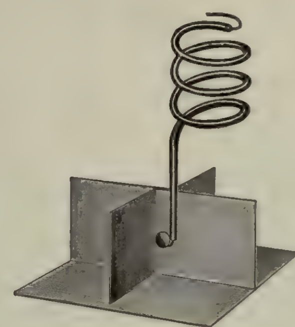


Figs. 2303-2304. Three-Leaf Coppers (with two 2-in. x 3-in. "Turnovers").

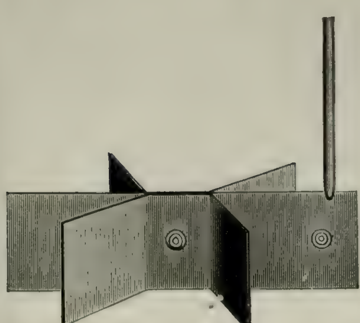
Fig. 2305. Two-Leaf Copper (with "Turnovers").

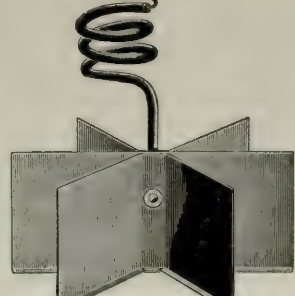






Figs. 2306-2308. "Pan Bottom" Coppers.





Figs. 2309-2310. Three-Leaf Coppers.

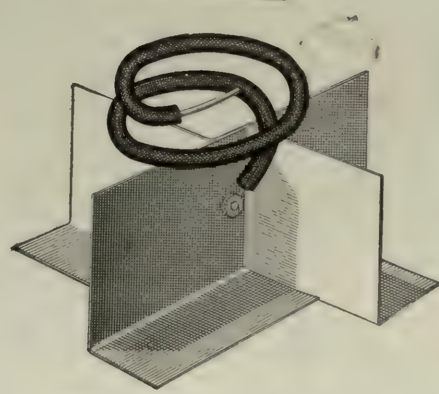


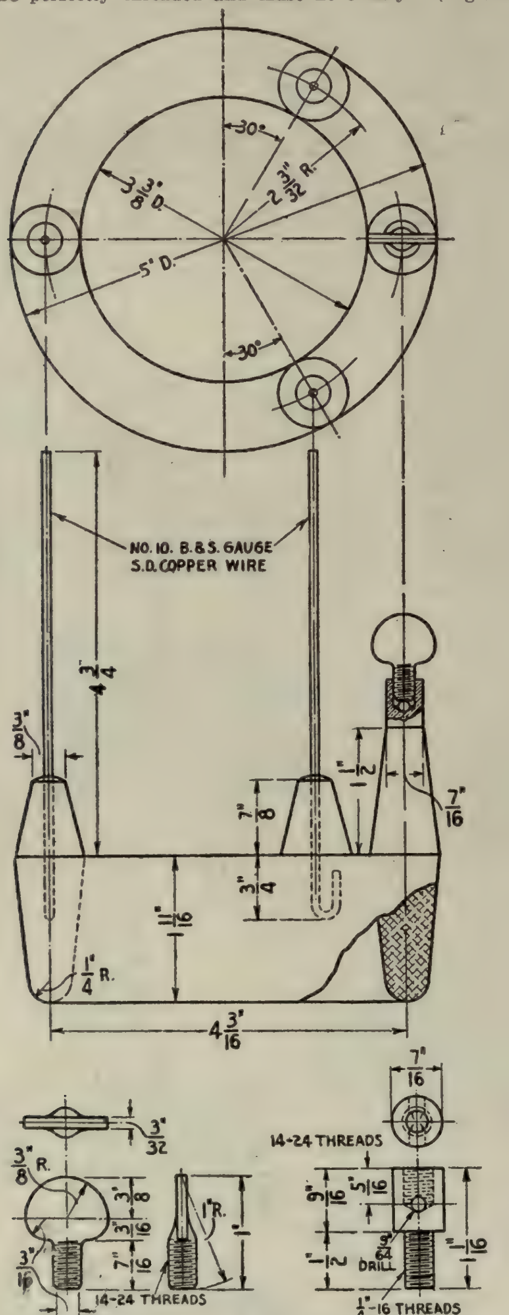
Fig. 2311. Two-Leaf Copper (with four 1¼-in x 3-in. "Turnovers").

Figs. 2303-2311. Types of Gravity Battery Coppers.

R. S. A. SPECIFICATIONS FOR GRAVITY BATTERY ZINCS.

1. Zincs shall be made from virgin spelter cast at a low temperature and shall be thoroughly amalgamated with mercury. They shall be uniform in size and weight, free from flaws and mechanical defects, and shall have a smooth outer surface. A fracture of the zinc must show the grain firm and close.

2. The size and shape of zincs shall conform closely to this drawing. The brass binding post must be firmly connected both mechanically and electrically to the zinc. The thumb screw must be perfectly threaded and must fit closely. (Figs. 2312-2315.)



Figs. 2312-2315. R. S. A. Standard Gravity Battery Zinc. (Zinc, Binding Post and Thumb Screw.)

The manufacturer's name must be cast on the upper flat surface of the zinc in as large letters as the zinc will permit and must be raised not less than 3-32-in. above the surface. In addition, the manufacturer's name or trademark must be stamped on some other part in such a position as not to be effaced by the action of the electrolyte or by the process of cleaning.

3. Weight, the zincs shall weigh four pounds each.

4. The chemical composition of the finished zincs shall be as follows:

Mercury	not less than	2.00 per cent.
Iron	not more than	.10 "
Lead	not more than	.50 "
Other impurities	not more than	.40 "
Zinc	not less than	97.00 "

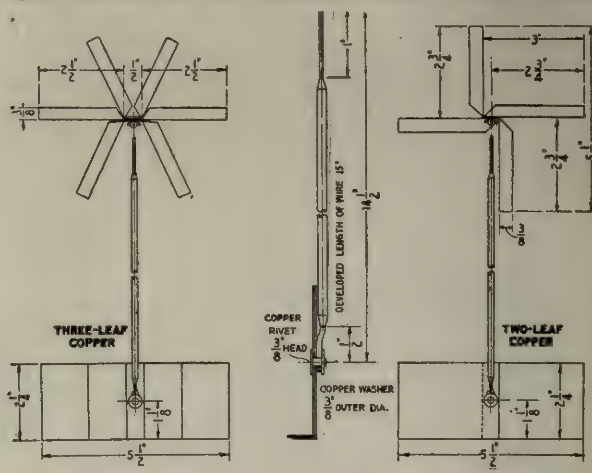
5. When a shipment of zincs is received, an examination will be made to see that the physical requirements are fulfilled, and if found satisfactory, one zinc from each 50 or fraction thereof will be taken for chemical analysis. The result of this analysis shall determine whether the shipment will be accepted.

In the event of controversy with the manufacturer over the chemical composition, one zinc from each 50 or fraction thereof shall be submitted to a disinterested chemist, acceptable to both manufacturer and purchaser, for an analysis. If in the analysis the chemical composition of the zincs analyzed is found to be in accordance with this specification, the zincs furnished will be accepted and the cost of the analysis shall be paid by the purchaser. If the chemical composition is not found to be in accordance with this specification, all expenses in connection with the analysis including the loss on the zincs analyzed shall be borne by the manufacturer.

The manufacturer shall be advised of all material rejected as a result of chemical analysis or physical tests, and if at the expiration of two weeks no instructions are received for the return of same, the rejected material shall be returned at the risk of the manufacturer, he paying the freight in both directions in either case.

The payment for zincs shall be based upon the net weight received.

6. Zincs must be carefully and securely packed in shavings or sawdust in a stout barrel or box, in lots not to exceed 50 each. The name of the manufacturer and the name of the consignee, together with the destination, number of zincs contained



Figs. 2316-2318. R. S. A. Standard Gravity Battery Copper.

in the package and the purchase order number must be plainly marked on the outside of each package.

All zincs broken in transit on account of not being properly packed will be returned to the manufacturer, who must promptly replace same free of cost to the purchaser.

7. Thumb screws for binding posts shall be furnished only when specified.

When furnished each box or barrel must contain at least as many thumb screws as there are zincs, the thumb screws being wrapped separately and tied to one of the zincs just under the cover.

R. S. A. SPECIFICATIONS FOR GRAVITY BATTERY COPPER.

1. Material. (a) Coppers shall be two-leaf or three-leaf as specified and shall conform to the above drawing. Leaves shall be No. 30 B & S gauge, hard rolled bright copper not less than 98 per cent pure. (Figs. 2316-2318.)

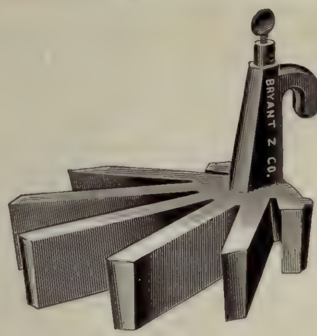
(b) Lead wire shall be No. 14 B & S gauge, solid soft drawn copper, insulated throughout the entire length, except one in. at each end. The insulation shall consist of a 3-64-in. wall of rubber, shall adhere tightly to the wire, and shall be of a character suitable to withstand the action of the battery solution. Insulation on ends of wire to be trimmed either tapered or square and in this operation the wire must not be scored.

(c) End of wire attached to copper must be thoroughly cleaned and tightly riveted as shown with a rivet having a ⅜-in. head and a washer ¾-in. in outer diameter. Both rivet and washer shall be copper not less than 98 per cent pure.

2. Packing and Marking. Coppers shall be carefully and securely packed in lots of 100 each, or 50 if so specified, and the purchase order number, contents of package, name of manufacturer, and name and address of consignee shall be plainly marked on the outside of each package.

3. Inspection and Acceptance. One copper taken at random from each 50 or fraction thereof shall be examined and tested.

Round Zinc.



"Crowfoot" Zinc."

Round Zinc.

Round Zinc.

Figs. 2319-2322. Types of Gravity Battery Zincs.

Fig. 2323. Gravity Battery Jar.

Fig. 2324. Gravity Cell Assembled.

The results of this examination shall determine whether the lots so represented will be accepted. If the samples are found to meet this specification, the material will be accepted. If any of the samples fail to meet this specification, the lots represented will be rejected and returned at the risk of the manufacturer, he paying the freight in both directions.

THE COLUMBIA TRACK BATTERY.

The Columbia track battery is a primary caustic soda cell having flaky copper oxide as a positive element, loosely placed on a tin disk to which a wire is riveted for electrical connection to the external circuit. The negative element consists of metallic zinc properly amalgamated, circular in form and suspended by means of wires from the edge of the jar containing the solution. This battery was designed primarily for railway signal service to replace the gravity or blue-stone cell. It has a relatively high internal resistance for a caustic soda cell, and yet lower internal resistance than that of the gravity cell. It does not require cleaning or attention from the time that it is put into service until the elements are exhausted. On account of its construction and the electrolyte it will not freeze nor evaporate. Owing to its high internal resistance no external resistance is needed between the battery and the track, and yet it is of sufficiently low internal resistance so that a severe rainstorm will not make the track insulation so bad that the relay will not hold up. The capacity of this cell is 350 ampere hours and it will give service from three to six months on tracks. The construction of the cell is shown in Fig. 2325

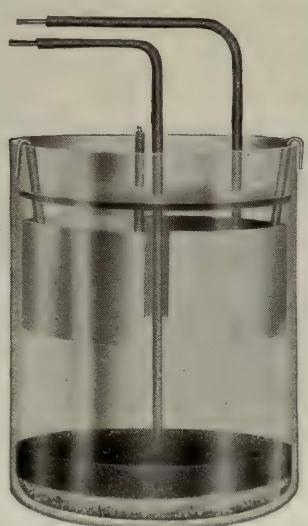


Fig. 2325. Columbia Track Battery. National Carbon Company.

Figs. 2326-2328. Types of Dry Battery. Nungesser Carbon & Battery Company.

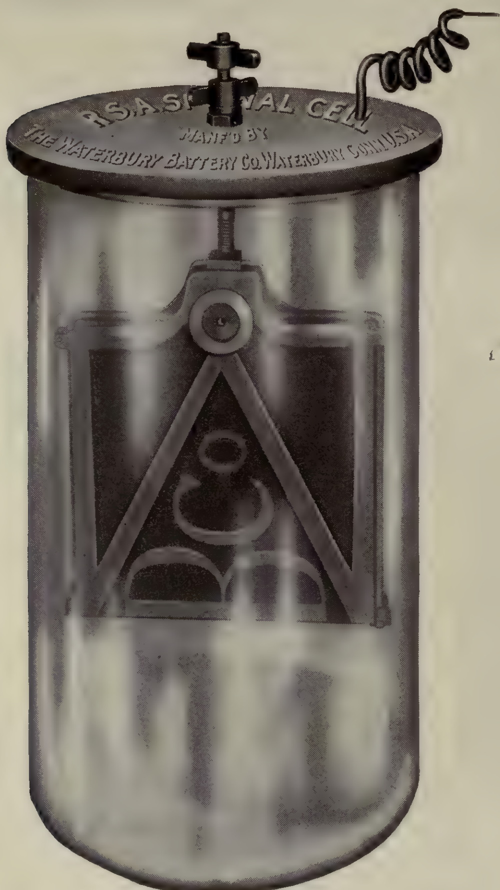


Fig. 2329. Schoenmehl Plate Type Copper Oxide Signal Cell, 400 a. h. Waterbury Battery Company.

Fig. 2331. Track Battery. Banks Electric & Manufacturing Company.

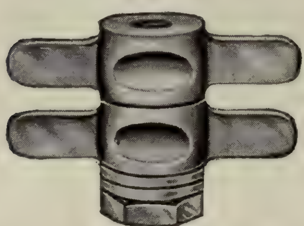
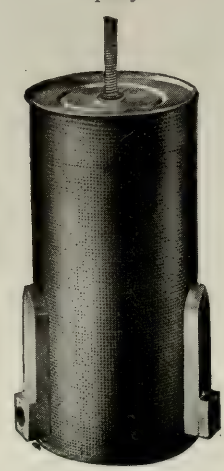


Fig. 2330. R. S. A. Standard Wing Nuts for Signal Battery.

Fig. 2332. Signal Battery. Banks Electric & Manufacturing Company.

Fig. 2333. Caustic Potash Battery. Railroad Supply Company.



Figs. 2334-2336. Gordon Signal Cell. Lutz-Lockwood Manufacturing Company.

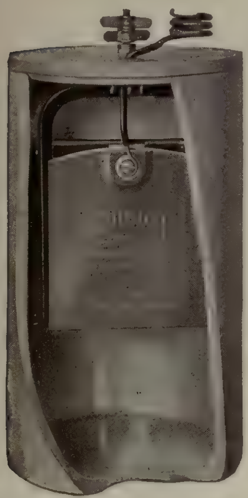
EDISON-BSCO CELLS.

The plates used in the Edison-BSCO primary battery are made of pure amalgamated zinc and compressed copper oxide. Each cell contains two amalgamated zinc plates, forming the positive electrode (negative pole), and one copper oxide plate constituting the depolarizer and negative electrode (positive pole). The electrolyte consists of caustic soda of a special grade, and water properly proportioned.

When a cell is on closed circuit and current flows, the caustic soda is decomposed and the sodium is carried to the oxide of copper plate, while the oxygen and hydrogen are carried to the zinc plates. The oxygen and hydrogen unite with the zinc, the result of the combination being hydrated oxide of zinc. This compound then dissolves in the free solution, and zincate of sodium is formed.

The sodium which goes to the copper-oxide plate, having a stronger affinity for oxygen than copper has for oxygen, takes oxygen away from the copper oxide and combines with it (the oxygen), forming sodium oxide. This immediately unites with some of the water of the solution, reforming caustic soda. The amount of soda reformed in this way is equivalent to the amount decomposed by the current, so that caustic soda is used up only as it combines with hydrated oxide of zinc to form zincate of soda.

The action of the cell gradually dissolves the zinc plates and converts the oxide of copper plate into a plate of pure



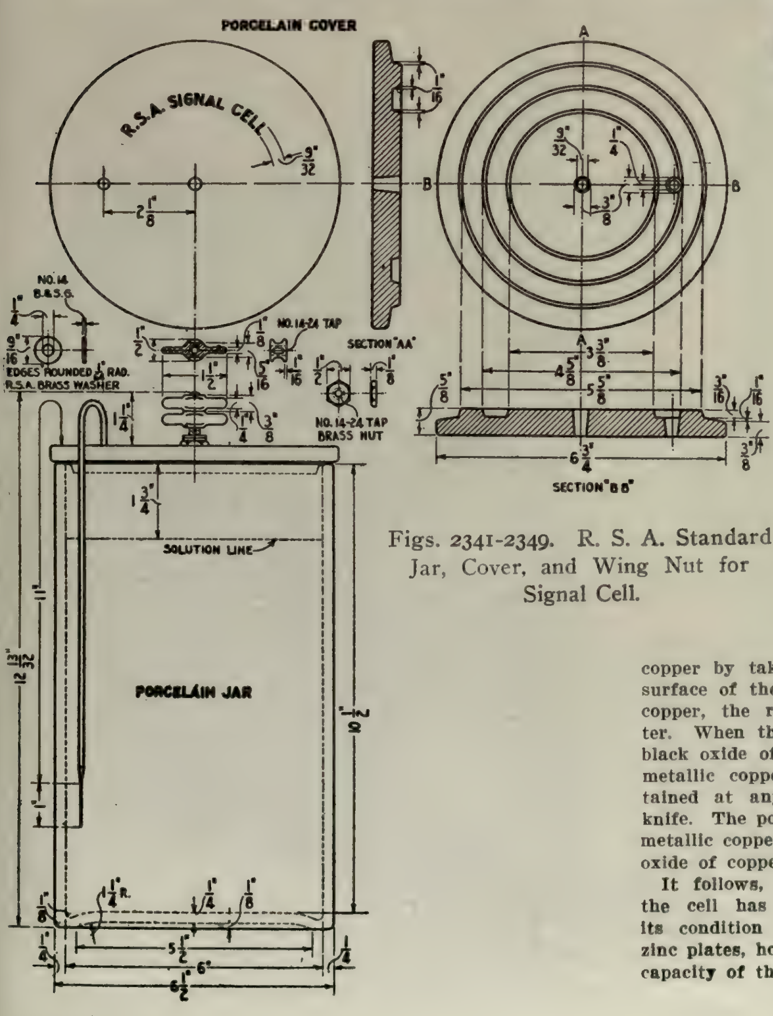
Type 401, 400 a. h. (Porcelain or Heat Resisting Glass Jar).

Type 402 (Rectangular) 400 a. h. (H. R. Glass Jars.)

Type 404 (Barrel Shaped) 400 a. h. (H. R. Glass Jars.)

Fig. 2340. Edison Type "SS" 350 a. h. Cell. Porcelain or H. R. Glass Jar.

Figs. 2337-2339. Edison BSCO Batteries. Thomas A. Edison, Inc.



Figs. 2341-2349. R. S. A. Standard Jar, Cover, and Wing Nut for Signal Cell.

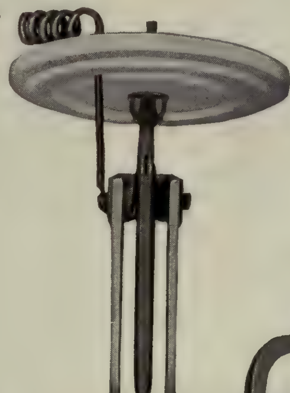


Fig. 2350. Edison BSCO Element and Cover Assembled.

Fig. 2351. Edison BSCO Renewal.

copper by taking away its oxygen. The copper oxide at the surface of the plate is the first to be converted into metallic copper, the reduction gradually penetrating toward the center. When the cell is exhausted all but a very thin layer of black oxide of copper in the center of the plate is reduced to metallic copper. The amount of unused oxide can be ascertained at any time by picking into the plate with a penknife. The portion that has been exhausted and converted into metallic copper will be red or copper color, while the unchanged oxide of copper will be black.

It follows, therefore, that the degree of exhaustion which the cell has reached can be determined in this way, but its condition can also be determined by examination of the zinc plates, holes appearing in the lower panels when the rated capacity of the cell has been discharged.

R. S. A. CAUSTIC SODA SIGNAL CELL.

The Railway Signal Association standard specifications for a caustic soda signal cell (see Figs. 2341-2349) are as follows:

Complete Cell. A complete cell consists of a jar, cover and renewal with one hexagon nut, two wing nuts and two washers as shown.

Renewal. A renewal consists of a sealed can of caustic soda, sealed bottle of mineral oil and assembled elements with connecting wire and rigidly connected suspension bolt. Nuts and washers shall be furnished with renewals only when specified.

The elements shall be so assembled that when attached to the cover and the nut on the upper side tightened to place, the elements will be at the proper height in the solution.

Connection to zinc shall be No. 12 B & S gauge solid soft drawn copper wire covered with an insulation suitable to withstand the action of the oil and electrolyte. Insulation on end of wire shall be trimmed either tapered or square and in this operation the wire must not be scored.

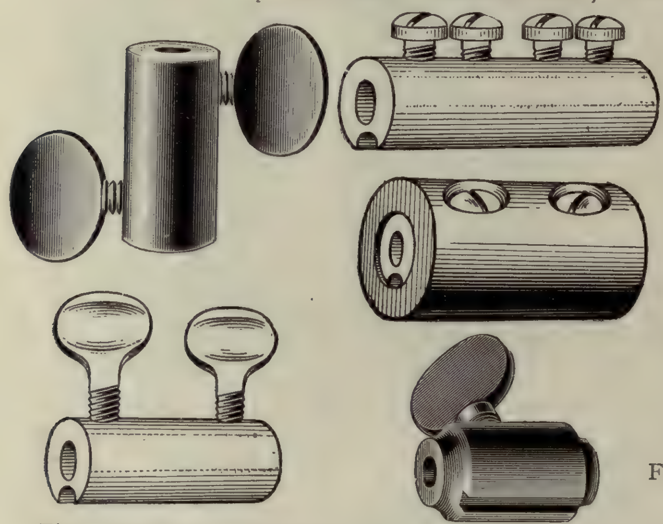
Suspension bolt shall be iron, copper plated.

Jar and Cover. Jar and cover shall conform to the dimensions shown, with reasonable allowance for slight irregularities in manufacture. Top of jar shall be square with vertical axis and cover shall be perfectly flat. Manufacturer's name or trade mark may be shown on cover. Porcelain jars shall be glazed inside and out and covers on top and edge.

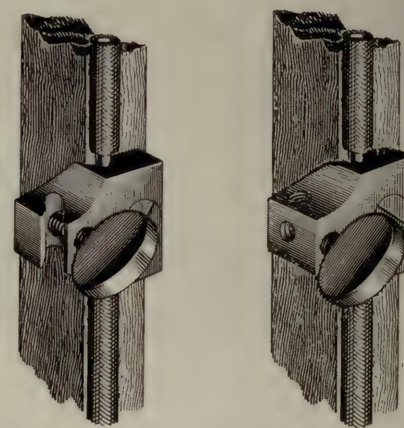
A solution line consisting of a slight ridge or depression extending around the inside of porcelain jars and the outside of glass jars shall be placed as shown.

For heat resisting jars, glass shall be three-sixteenths (3-16) in. thick and inside dimensions shall be as shown with reasonable allowance for slight irregularities in manufacture.

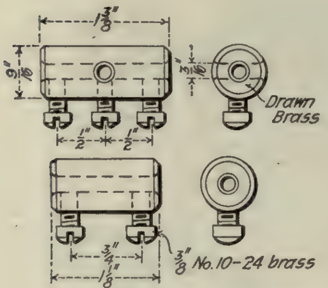
BATTERY CONNECTORS, ELEVATORS AND SHELTERS



Figs. 2352-2356. Types of Battery Wire Connectors.



Figs. 2362-2363. Wire Fasteners for Battery Elevator. Shown in Fig. 2364 (on left). Bryant Zinc Company.



Figs. 2357. Battery Wire Connectors.

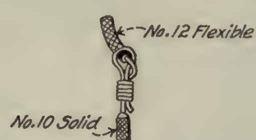


Fig. 2358. Joint Between Solid and Flexible Wire, for Use at Battery Chutes.

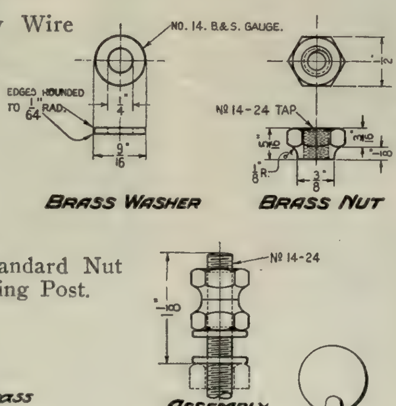


Fig. 2359. R. S. A. Standard Nut and Washer for Binding Post.

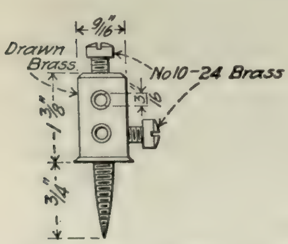


Fig. 2360. Binding Post for Copper Terminal or Gravity Battery.

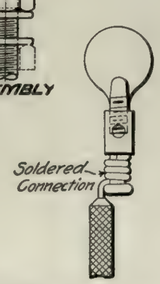


Fig. 2361. Battery Connector Soldered to Wire.

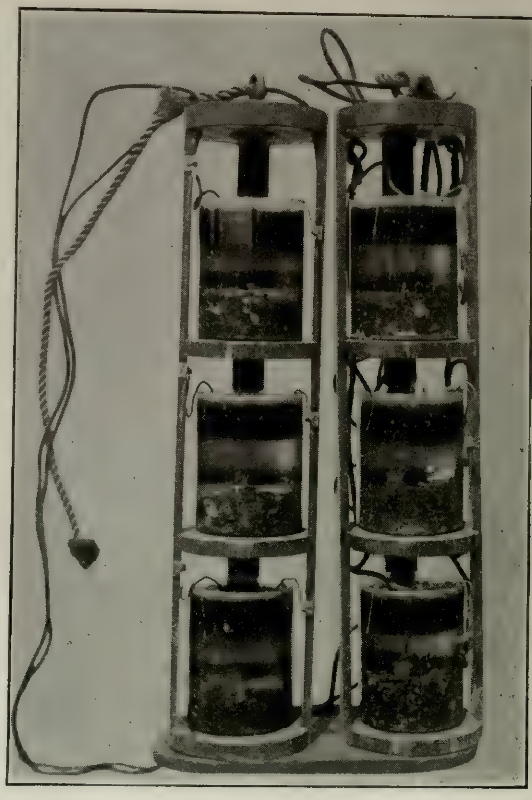


Fig. 2364. Battery Elevators Showing a Common Method of Wiring (on right) and an Improved Method Using Wire Fasteners (on left). Bryant Zinc Company.

Fig. 2365. Concrete Battery Box. C. F. Massey Company.

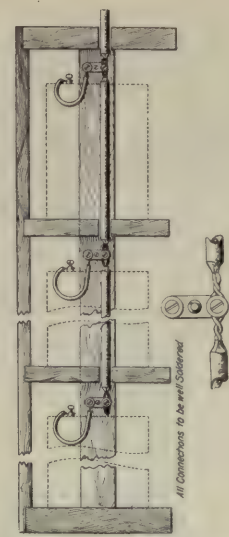
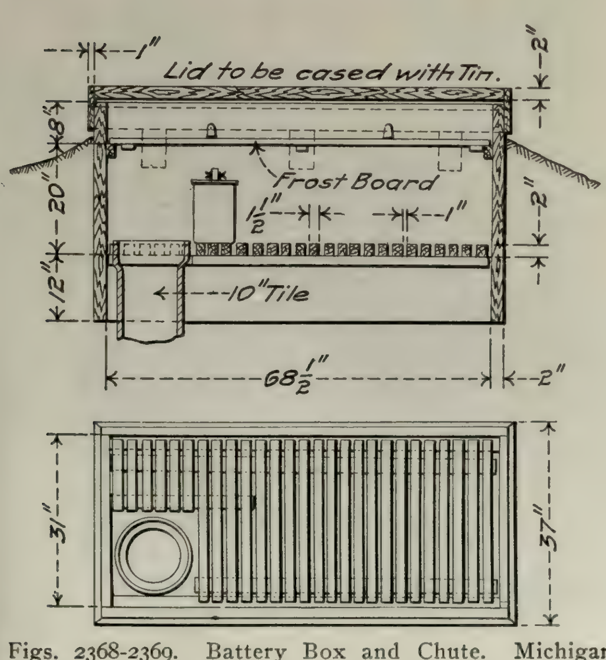


Fig. 2366. Wiring for Battery Elevator. Atchison, Topeka & Santa Fe.

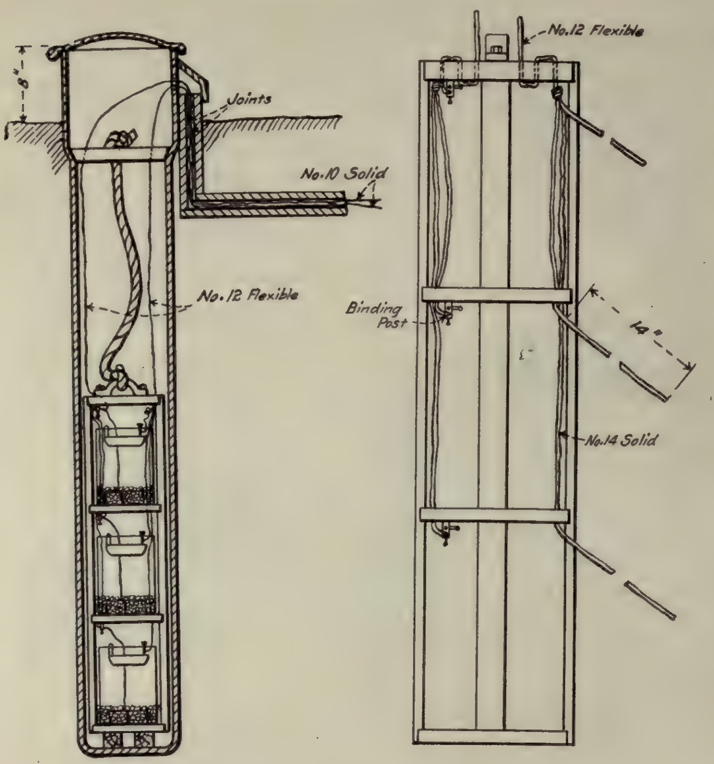
Fig. 2367. Cast Iron Battery Box.



Figs. 2368-2369. Battery Box and Chute. Michigan Central.

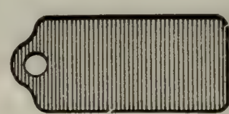
Fig. 2370. Single Cast Iron Battery Chute. Bryant Zinc Company.

Fig. 2371. Double Cast Iron Battery Chute. Railroad Supply Company.

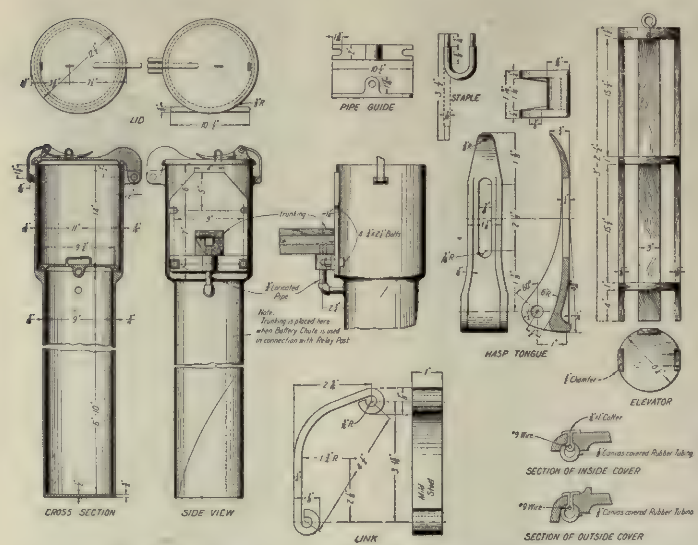


Figs. 2372-2373. Elevator and Standard Arrangement of Cells in Battery Chute. Southern Pacific-Union Pacific.

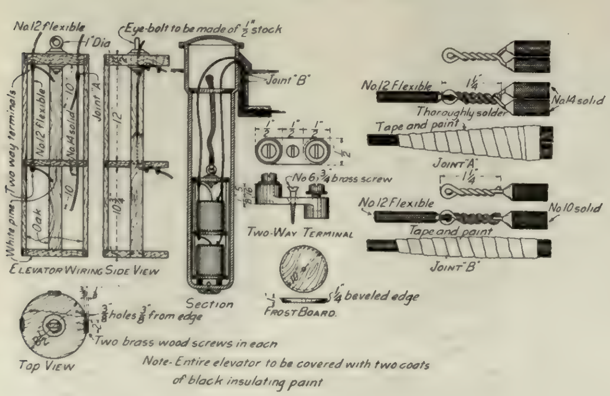
Fig. 2374. Cast Iron Battery Chute. Bryant Zinc Company.



Figs. 2388-2392. Wire Tags.



Figs. 2375-2382. Details of Special Battery Chute. Northern Pacific.



Figs. 2383-2387. Battery Chute and Wiring. Sunset Lines.

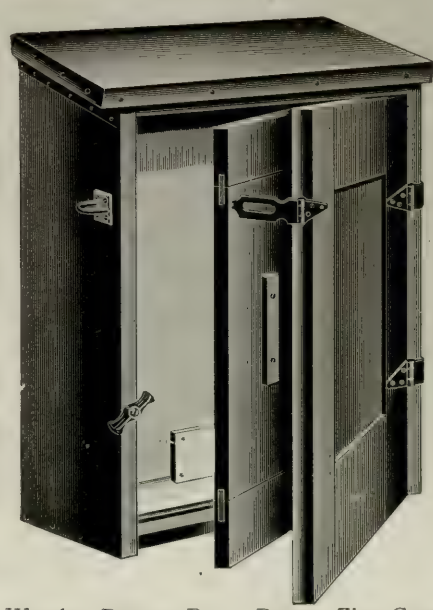


Fig. 2393. Wooden Battery Box. Bryant Zinc Company.

Fig. 2394. "Ironcrete" Battery Chute. Potter-Winslow Company.

Fig. 2395. Cast Iron Battery Chute. Railroad Supply Company.

BATTERY ELEVATORS.

Fig. 2396 shows the automatic elevator for battery chutes made by the Bryant Zinc Co. It consists of a regular elevator. to which have been added three metal rods. These rods are fastened at the lower end in a wooden disc, which is the same size as the elevator. The rods pass through holes near the outer edge of the different shelves of the elevator. When the elevator is pulled up out of the chute, the bottom disc drops down until it is 20 inches below the bottom of the elevator proper. When the bottom of the elevator reaches the top of the chute, a locking dog automatically extends out over the side of the chute. The elevator will now rest on this locking dog.

The three rods extending downward into the chute to the lower disc will support the elevator in an upright position, while batteries are being changed or renewed. When it is desired to lower the elevator, it is only necessary to give it a slight twisting motion, which will unlock the supporting device and allow the elevator to be lowered to bottom of chute.

Other forms of battery elevator are shown in Figs. 2370-2371, 2397-2399, and 2366, the latter showing a form of wiring used by the Atchison, Topeka & Santa Fe.

BATTERY CHUTES.

Figs. 2397-2399 show battery chutes made by the C. F. Massey Co. These are 7 ft. long and 10 in. inside diameter. They are cast in one piece from waterproof cement reinforced by a steel cage, and are provided at the top with a cast iron ring to which the cover is attached. The weight of the chute is 485 lbs. Nine-foot chutes of similar construction weigh 525 lbs.

Fig. 2395 shows a cast iron battery chute to which is attached a trunking cap. The figure shows also how the trunking is fitted into the cap. In Fig. 2394 a reinforced concrete chute is shown with a trunking cap. Figs. 2397-2399 show provisions for three forms of attaching the trunking or conduit carrying the wiring to the chute.

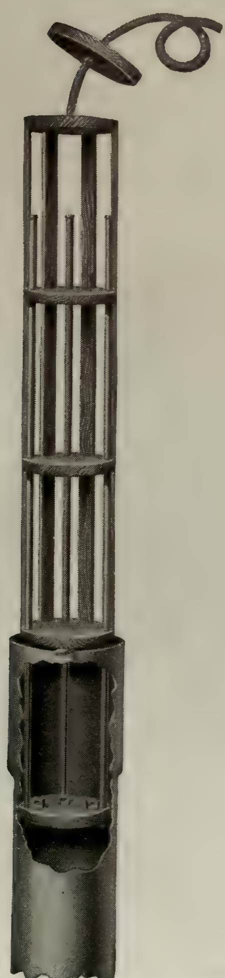
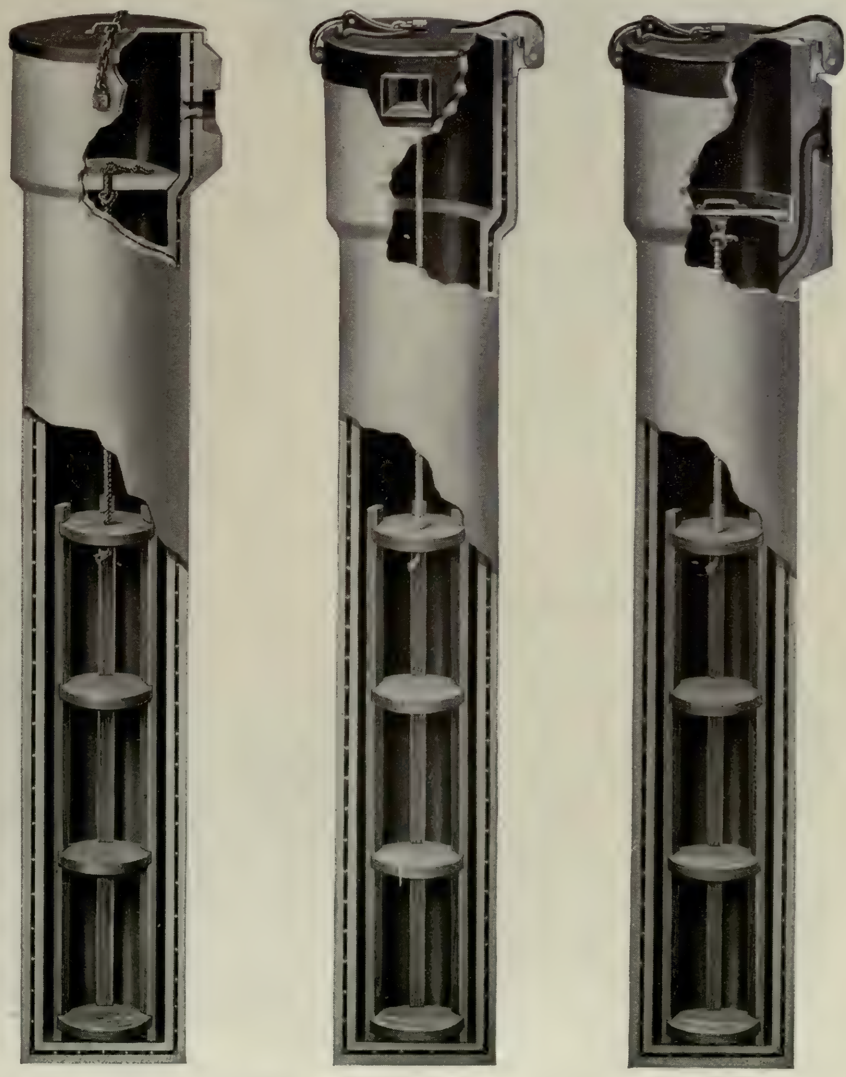
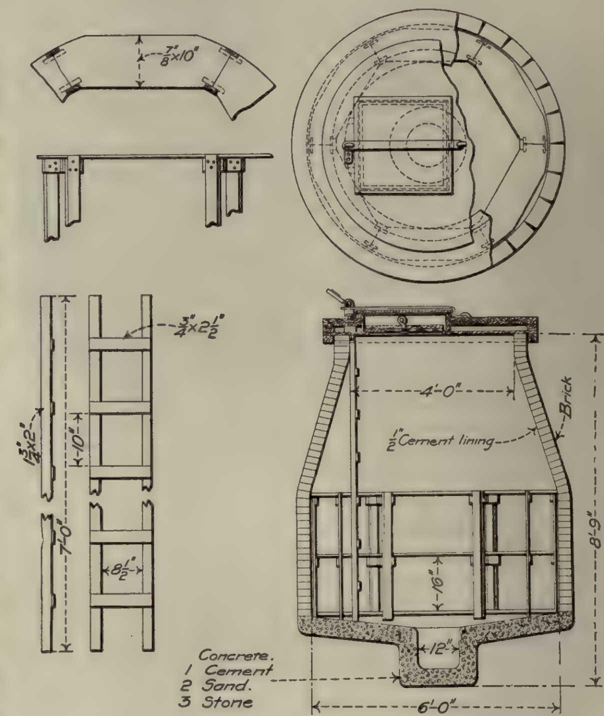


Fig. 2396. Automatic Battery Elevator. Bryant Zinc Company.

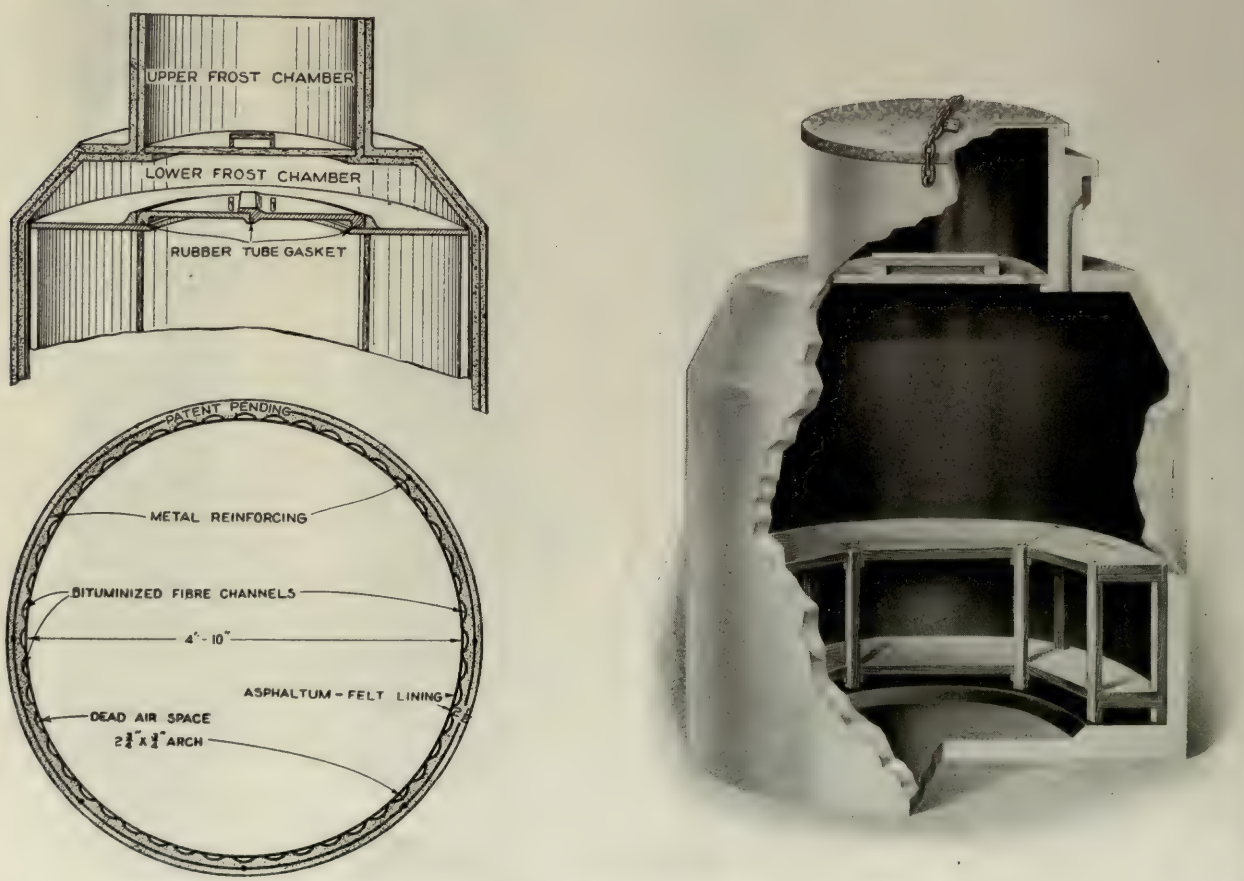


Figs. 2397-2399. Cement Battery Chutes. C. F. Massey Company.

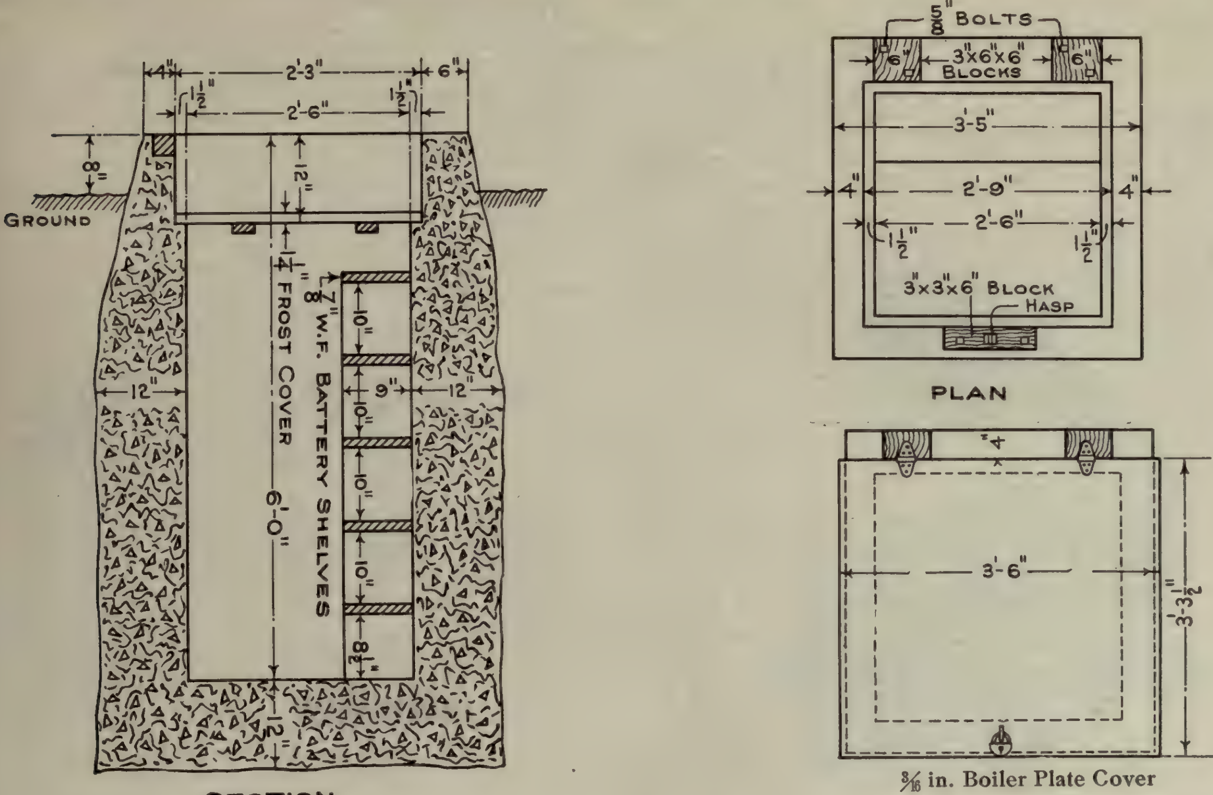
Fig. 2400. Reinforced Concrete Battery Well. C. F. Massey Company.



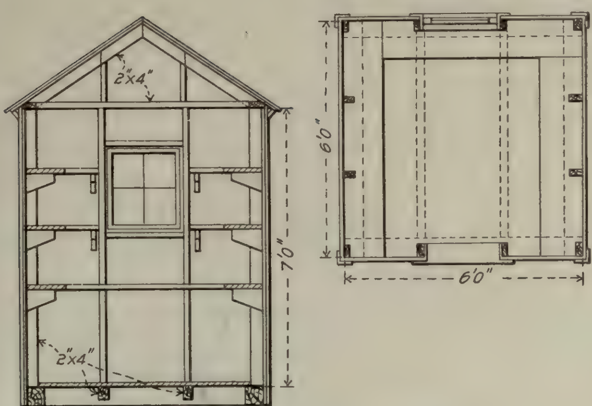
Figs. 2401-2404. Brick Battery Well. New York Central & Hudson River.



Figs. 2405-2406. Reinforced Concrete Battery Vaults. Potter-Winslow Company.

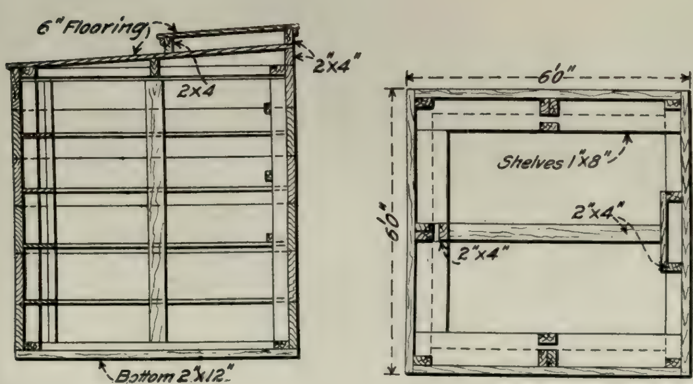


Figs. 2407-2409. Standard Concrete Battery Well. New York, Ontario & Western.



Figs. 2410-2411. Battery House. Michigan Central.

Fig. 2412. Relay Box. Railroad Supply Company.



Figs. 2413-2414. Wooden Battery Cellar. Chicago & North-Western.

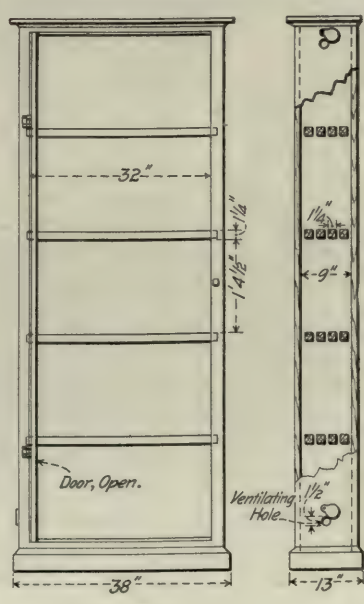


Fig. 2415. Battery Cupboard. Michigan Central.

CIRCUIT CONTROLLERS

SWITCH BOXES

HALL STYLE "G" SWITCH BOX.

Fig. 2416 shows the Style "G" Switch Box made by the Hall Signal Co. The contacts of this instrument are so arranged as to be used normally open or normally closed, or any combination of contacts may be obtained by a proper connection of circuits.

Fig. 2416. Hall Style "G" Switch Box.

Each spring is provided with a front and back connection, with separate binding posts, and is forced mechanically in one direction.

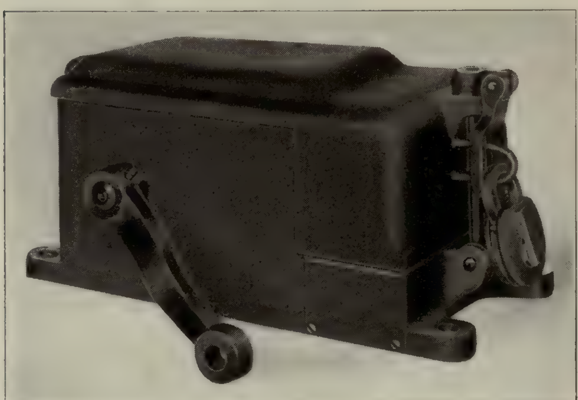


Fig. 2417. Style "G" Switch Box Complete.

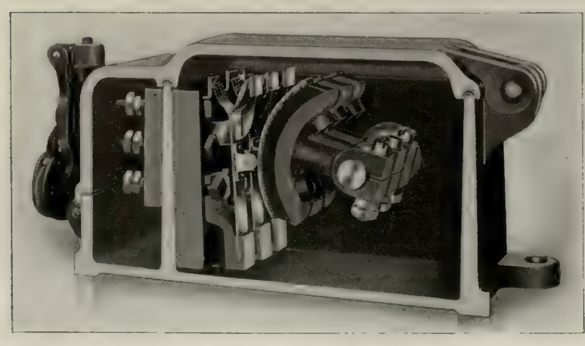
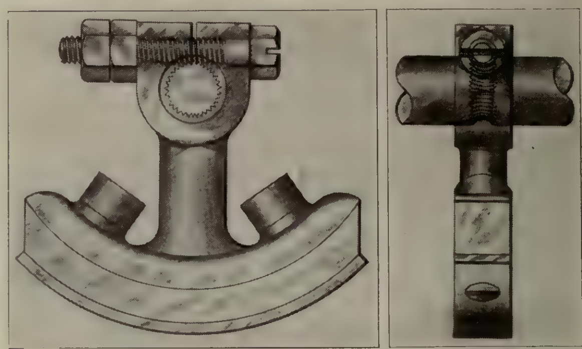


Fig. 2418. Hall Style "G" Switch Box with Side Cut Away to Show Contacts.

The operation of the contacts is accomplished by segments which are independently adjustable, the adjustment being permanent when made, as the operating arms are locked on the shaft by a worm gear arrangement which prevents slipping, and requires the turning of a bolt by screw driver or wrench in order to change the adjustment.

If a contact is used as a shunt the connections to binding posts are made in such a manner that the contact is mechanically forced closed by the movement of the switch point one-eighth in., and is held mechanically in that position until the switch is returned to its normal position.

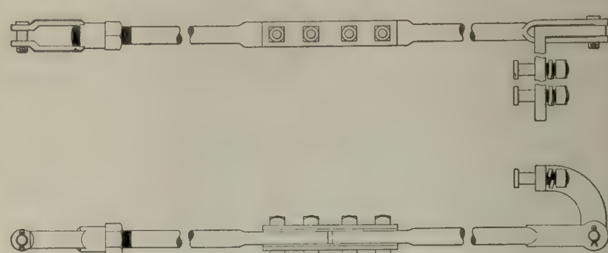
If a contact is used for opening a line circuit, the connections to the binding posts are so made that the contact is



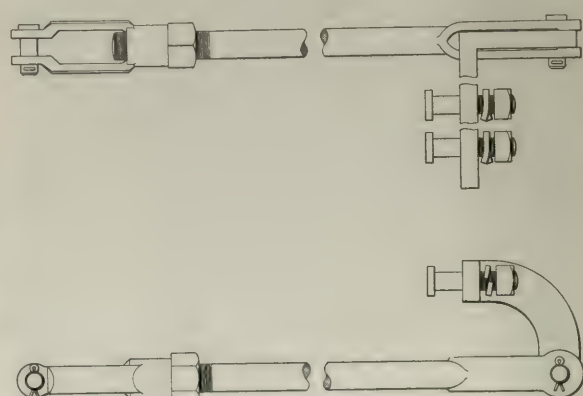
Figs. 2419-2420. Showing Method of Adjusting Hall Style "G" Switch Box.

mechanically forced open by the first movement of the switch, and held open mechanically until the switch is returned to its normal position. There is no dependence on the operation of any spring for the display of a danger signal, and it is impossible for a fused contact to hold a circuit closed.

The binding posts extend through one end of the case in such a manner that the wire connections are made in a sep-



Figs. 2421-2422. Hall Insulated Rod With Switch Lugs for Style "G" Switch Box.



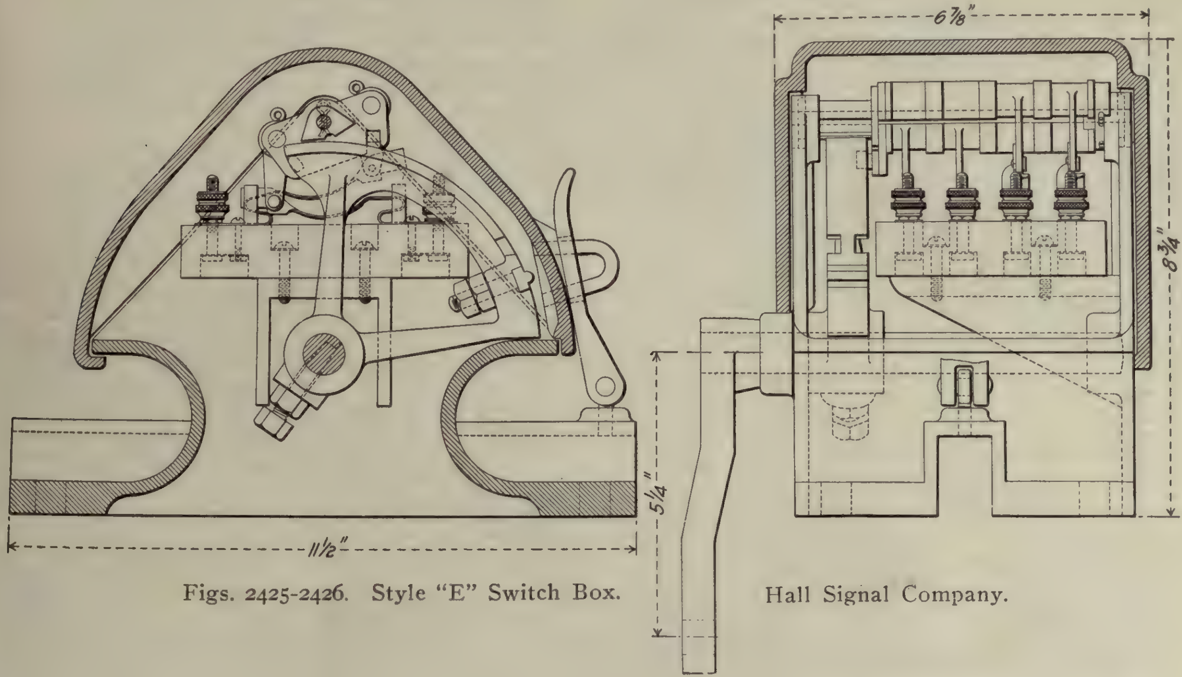
Figs. 2423-2424. Plain Rod With Switch Lugs for Style "G" Switch Box.

arate compartment from that containing the contacts and moving parts of the apparatus.

That portion of the cover which protects the contacts and

movable parts of the instrument is fitted with a tubular rubber gasket which is securely fastened in a groove which is provided for that purpose.

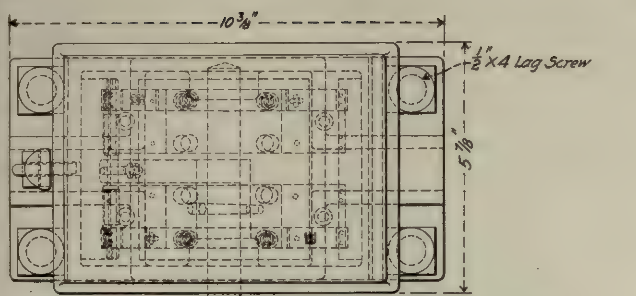
The hasp is attached to a threaded nut by which means the cover may be closed sufficiently tight to exclude dust and water. This switch box stands six and three-quarter in. high over all, and is so arranged that it may be changed from left-hand to right-hand or vice versa.

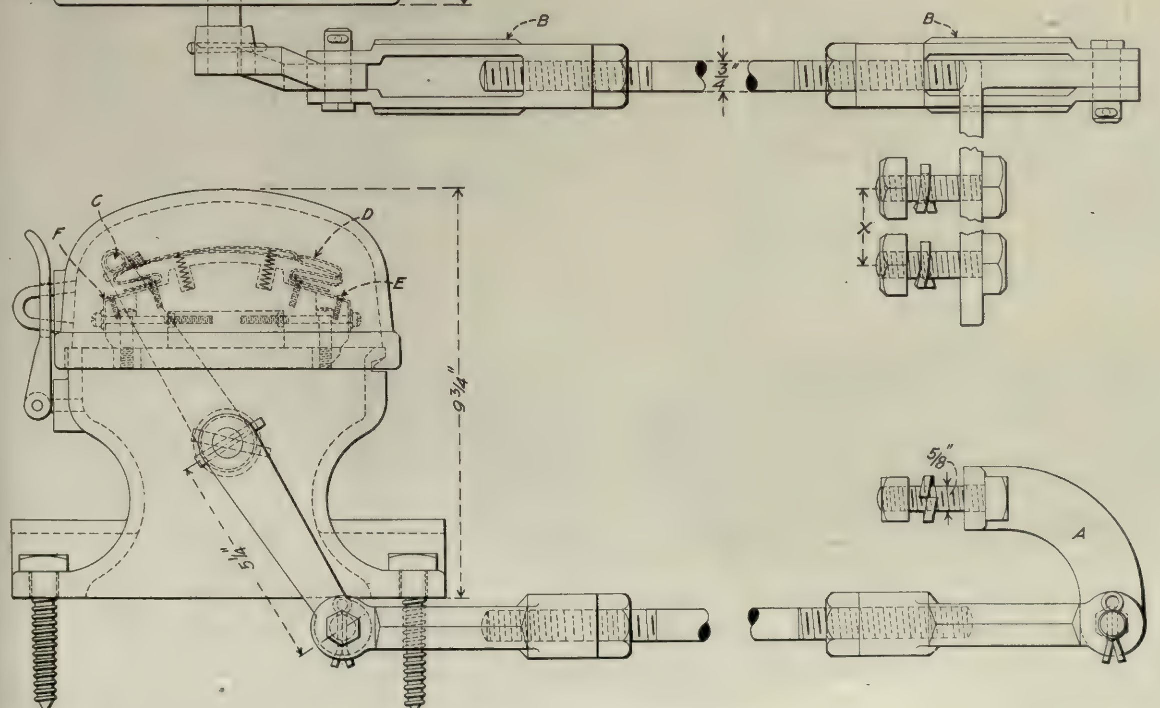


Figs. 2425-2426. Style "E" Switch Box. Hall Signal Company.

Names of Parts of the Hall Style "C" Switch Box; Figs. 2427-2428.

- **A** *Switch Point Lug*
- **B** *Screw Jaw*
- **C** *Lignum Vitae Roller*
- **D** *Contact Spring, with Platinum Contact*
- **E** *Spring Anvil, with Platinum Contact*
- **F** *Heel of Contact Spring*





Figs. 2427-2428. Style "C" Switch Box. Hall Signal Company.

UNION ELECTRIC SELECTOR.

The selector shown in Fig. 2429, is for controlling four circuits in either extreme position and can be worked directly from switch points or from the slide bar of a switch and lock

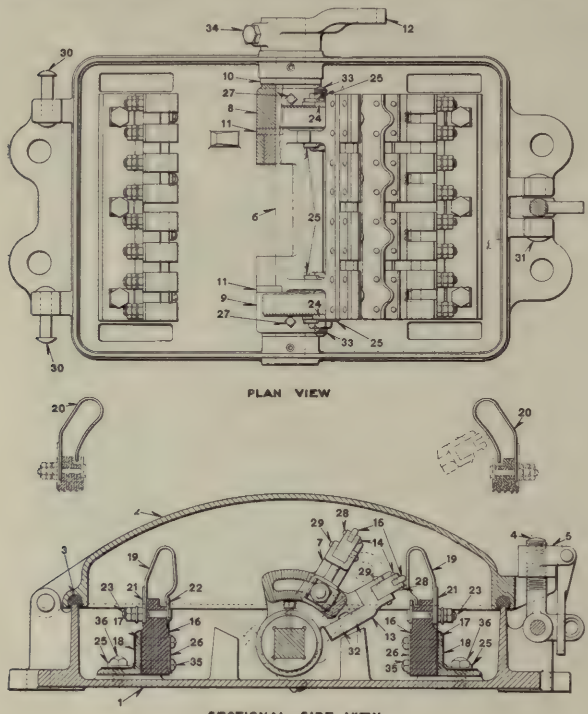


Fig. 2429. Electric Selector for Four Circuits in Each Direction, Operated by Switch Points and by Switch and Lock Movements. Union Switch & Signal Company.

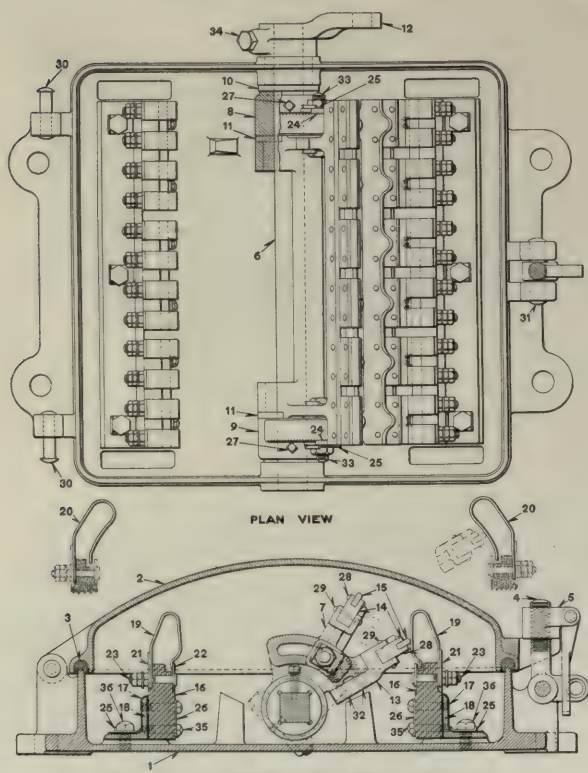


Fig. 2430. Electric Selector for Six Circuits in Each Direction, Operated Same as Fig. 2439.

movement. When operated directly from the switch points it can be adjusted to open when point has moved ⅛ in., and when operated from slide bar of a switch and lock movement it can be adjusted so that there is at least a half-inch wipe or slide on the springs before the circuit is broken.

The contact carriers are adjustable for variable throws of switches and the operating arm can be turned up or down and placed on either side of the box to suit conditions.

The selector shown in Fig. 2430, controls six circuits in either extreme position. It is similar in all respects to Fig. 2429.

UNION UNIVERSAL SWITCH CIRCUIT CONTROLLER.

The switch circuit controllers illustrated in Figs. 2431 and 2432 are universal in that the same box and fittings are used for either two or three position work, the only difference between the controllers being in the number and style of cams

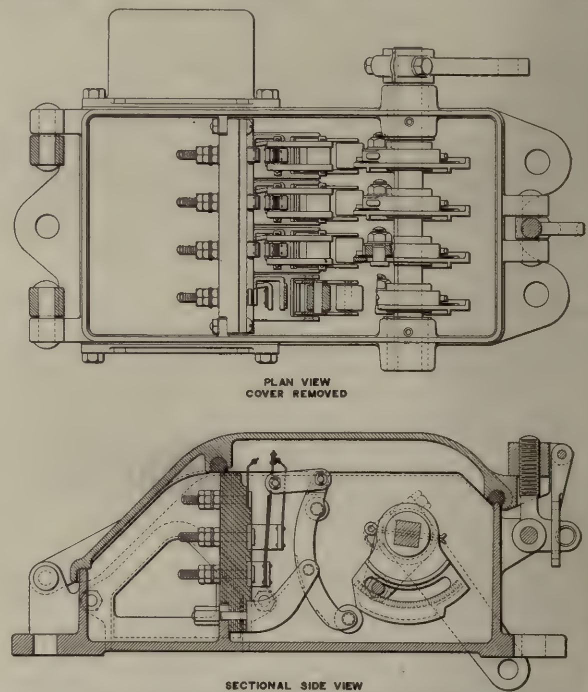


Fig. 2431. Universal Switch Circuit Controller. Union Switch & Signal Company.

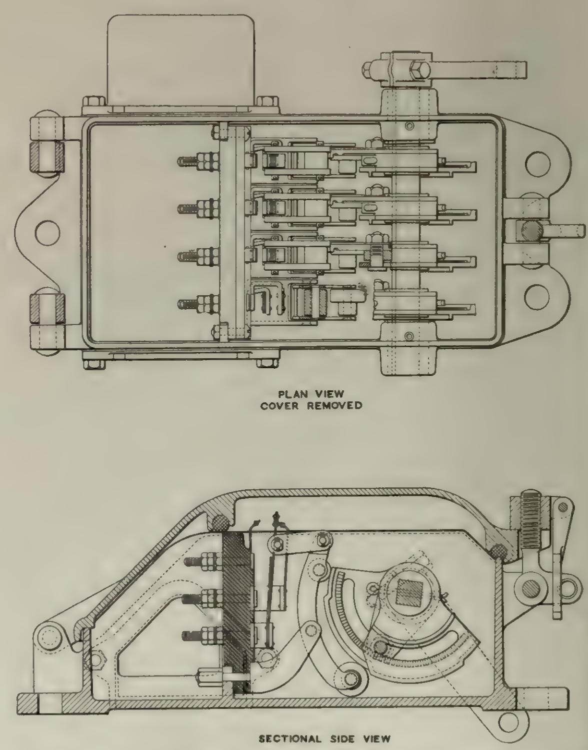


Fig. 2432. Universal Switch Circuit Controller. Union Switch & Signal Company.

used, and the two-position having one and the three-position two adjustable cams per set of contacts.

The operating arms and arms for carrying the cams are mounted upon a square shaft. The controller can be placed on either side of the track and have the cover open away from

the rails; is six and three-quarter in. high and is designed for application to any switch having not more than five and one-half in. throw.

The two-position controller can be equipped with either front or back contacts, and is adapted for shunting track circuits. The three-position controller can be equipped with front and back contacts and double adjustable cams, giving it a selective feature. Contacts in both the two and three position controllers are positively forced open or closed by the cams.

The contacts and operating mechanism are placed in a dust and dirt proof compartment separate from the terminal compartment, keeping all wearing parts free from dirt.

The contact springs and operating levers are mounted upon the same bakelite terminal block, thus allowing all parts to be removed from the box without disturbing the adjustment. The terminal block is a moisture and heat proof insulation of great mechanical strength and its use eliminates the insulation between the block and contact springs and between the terminal block and terminal posts.

All contacts are in plain view, easily accessible and each spring can be separately removed. Standard 14-24 binding posts are used.

The wires are brought into the terminal compartment through trunking and protected at the top by a cast iron hood.

A centering device to return the operating arm to a central position in case of a broken or disconnected operating rod may be added if desired.

Figs. 2433-2434. Vertical Rotary Switchbox, Model 2. The Union Switch & Signal Company.

Figs. 2433-2435 show the vertical rotary switchbox, Model 2, made by The Union Switch & Signal Company, a style generally used in automatic block signaling. The box is usually fixed to a tie, about 3 ft. from the track. The movement of the switch points closes contacts in the box which connect the opposite rails of the track, so as to de-energize the track relay, and thus throw to the stop position the home signal for that section, as in Fig. 475. Contacts may also be arranged to break the control circuits for signals when the switch is open. The driving or connecting rod is fastened to the switch rail by a lug bolted close to the point on the normally closed side. Adjustment is provided so that the opening of the switch point, as much as ¼ in., will operate the circuit controllers in the box. The wires are brought into the box through a hole in the tie to binding posts connected with the contact springs which are guided by a crosspiece. The crosspiece is operated to move the springs by a roller engaging a cam revolved by a shaft. The shaft is turned by a crank driven by the connecting rod. There is a large lug on the bottom of the case which is set into the tie as shown, holding the box in place.

Figs. 2436-2437 show a switchbox made by the General Railway Signal Company and used on the Electric Zone of the New York Central & Hudson River. It is provided with three normal and three reverse contacts, the six springs on each side constituting three pairs, each pair being bridged by a brass contact plate. These plates are carried by hard rubber blocks attached to the top of the contact arm. The lower part of the contact arm is formed into a jaw at one end, and those jaws are engaged by the operating arms, which are adjustable. The adjusting arm A is rigidly attached to the shaft, which is moved by the operating lever.

When the switch is normal, the parts assume the position

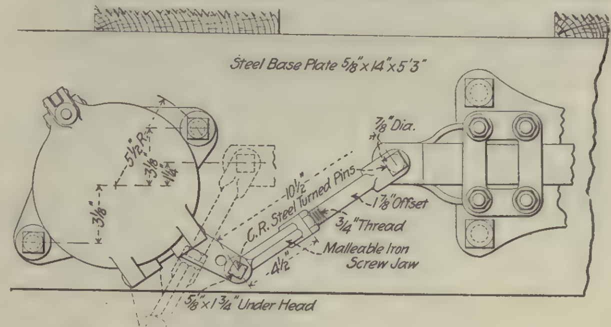
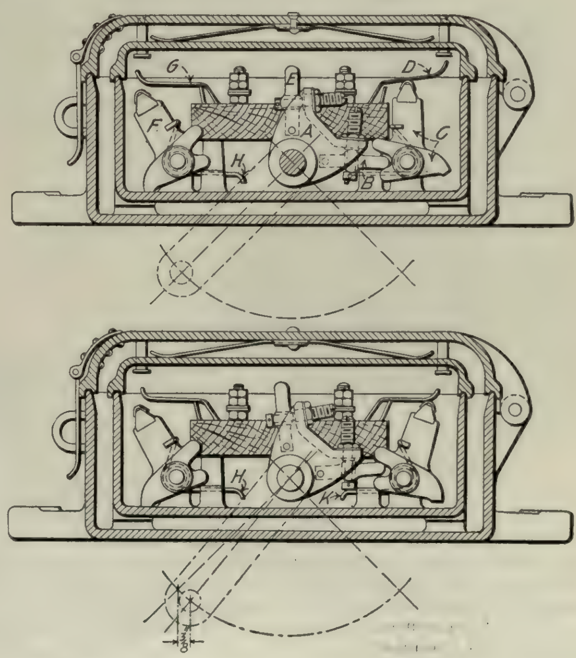


Fig. 2435. Vertical Rotary Switchbox, Figs. 2433-2434. Operated by Switch and Lock Movement. Pennsylvania Railroad.

Names of Parts of Switchbox. Figs. 2436-2437.

- **A** *Adjusting Arm*
- **B** *Right-Hand Operating Arm*
- **C** *Right-Hand Contact Arm*
- **D** *Right-Hand Contact Spring*
- **E** *Left-Hand Operating Arm*
- **F** *Left-Hand Contact Arm*
- **G** *Left-Hand Contact Spring*
- **H** *Left-Hand Contact Spring*
- **K** *Right-Hand Spiral Spring*



Figs. 2436-2437. Sectional View of G. R. S. Switchbox.

shown in Fig. 2436. The operating arm B engages the jaw of the contact arm C, forcing it downward and drawing up the contact plates against the springs D, bending them upward. This holds the three normal contacts closed. As the switch starts to move to its reverse position, B is raised and the spiral spring K forces C away from the contact springs. However, if the spiral spring should be broken the operating arm B would accomplish the same result before disengaging with the jaw.

G. R. S. UNIVERSAL SWITCH BOX.

The Model 5 Form A switch box (Fig. 2440), which is made by the General Railway Signal Co., can be used for shunting or breaking track circuits, for opening line circuits or for selecting circuits.

Contacts, of which there are four normal and four reverse, are designed to control voltages up to and including 220. By the use of supplemental cover, contacts are protected from frost and condensation, and, when main cover is open, from rain; contacts are all mounted on one panel of slate which is removable without interfering with contact adjustment; contacts are forced open and forced closed, spring action only not being relied upon.

The operating crank has a maximum throw of six inches, and may be placed on either side of box. The height of the box is six inches. A centering mechanism which will automatically open all the circuits if operating rods become disconnected can be provided.

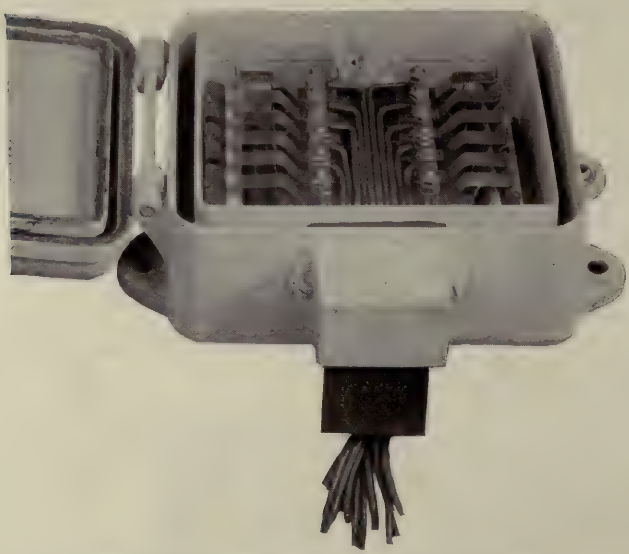


Fig. 2438. Switchbox, with Cover Open.

Fig. 2439. Switchbox and Selector.

Fig. 2441.

Fig. 2440. Model 5, Form A, Shunt Switch Box. General Railway Signal Company.

Fig. 2443.

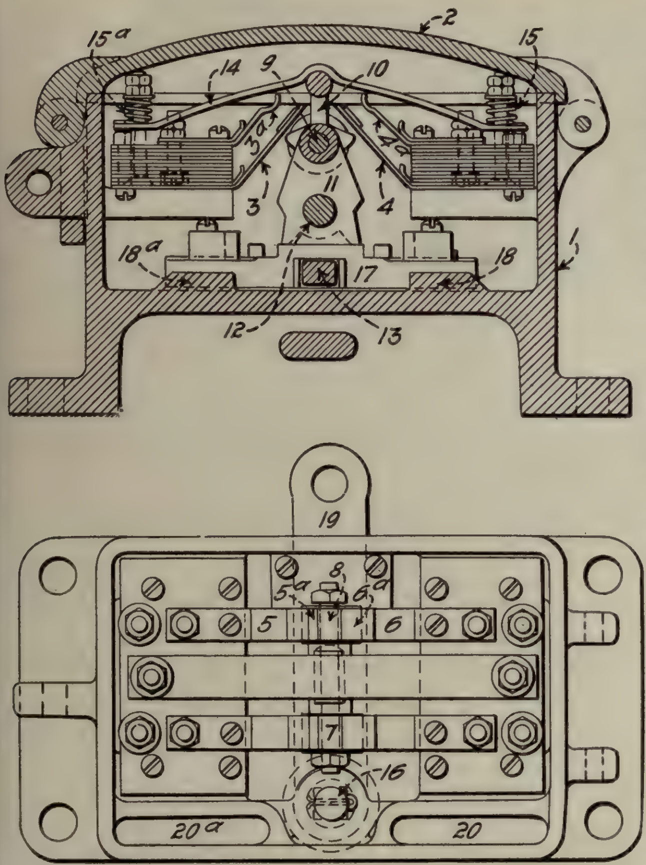
Fig. 2442.

Fig. 2444.

Figs. 2441-2444. High Voltage Switch Boxes. General Railway Signal Company.

When the operating lever is in the center of its stroke, neither jaw is engaged and all contacts are open. In the last ⅝ in. of its stroke, the operating lever brings the operating arm E into engagement with F, closing the reverse contacts G, in the same manner as were D in the extreme normal position.

It will be seen from the above that this switchbox is designed for use where control circuits are broken and is not desirable where track circuits are to be shunted. The switch shown in Figs. 2459-2461 is designed for shunting purposes.



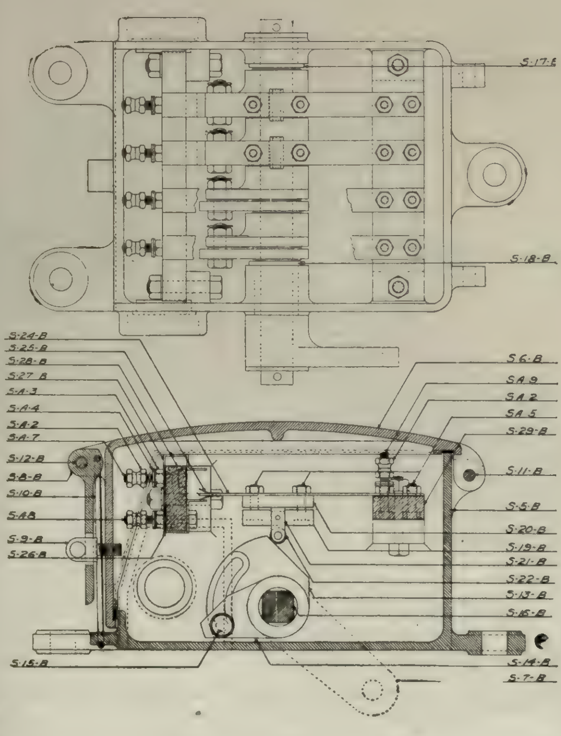
Figs. 2445-2446. Switchbox.

Figs. 2445-2446 show a switchbox in which are mounted contacts 3, 3-A, 4, 4-A, 5, 5-A, 6 and 6-A, which are closed by the insulated rollers 7 and 8, carried by toggle pin 9. The toggle is composed of link 10 and tumbler 11, which hangs on pin 9. The tumbler 11 rotates on stationary spindle 12, and is actuated by the slide 17. The upper end of link 10 engages with the concave portion of yoke 14, which is forced down against the upper end of toggle 10 by helical springs 15 and 15-A. The tongue 13 is attached to vertical spindle 16 and engages with and moves slide 17 in guide 18 and 18-A. This slide engages the portion of tumbler 11, which is below spindle 12, and as slide 17 moves either to right or left, it causes tumbler 11 to swing on spindle 12 until the hinge pin 9 reaches a point on either side of center. After reaching this point, the springs 15 and 15-A force the yoke 14 down, causing the toggle to close contacts on the side to which it swings. The vertical spindle 16 extends through the bottom of case 1 and attached to it is crank arm 19. This arm is operated to left or right by the switch point.

The circuit to be opened is broken during the first 3 deg. of movement of the crank 19, and the circuit to be closed is made up during the last 3 deg. of movement of the crank. During the intermediate movement of the crank, the contacts remain in the portion shown. Other arrangements of contacts can be made; contacts may be made up during the first 3 deg. of movement of crank and othersr remain closed until the last 3 deg. of movement of crank 19.

Names of Parts of Switchbox; Figs. 2445-2446.

1	*Case*	13	*Tongue*
2	*Cover*	14	*Yoke*
3-6a	*Contact Springs*	15-15a	*Helical Springs*
7-8	*Insulated Rollers*	16	*Vertical Spindle*
9	*Toggle Pin*	17	*Slide*
10	*Toggle Link*	18-18a	*Guide S*
11	*Tumbler*	19	*Crank Arm*
12	*Horizontal Spindle*	20-20a	*Openings for Wires*



Figs. 2447-2448. Model "B" Switch Box. American Railway Signal Company.

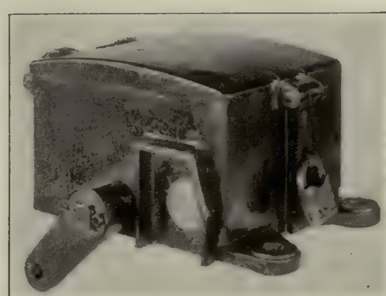


Fig. 2449. Model "B" Switch Box. American Railway Signal Company.

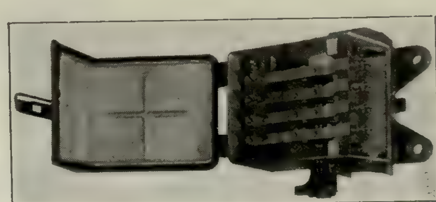
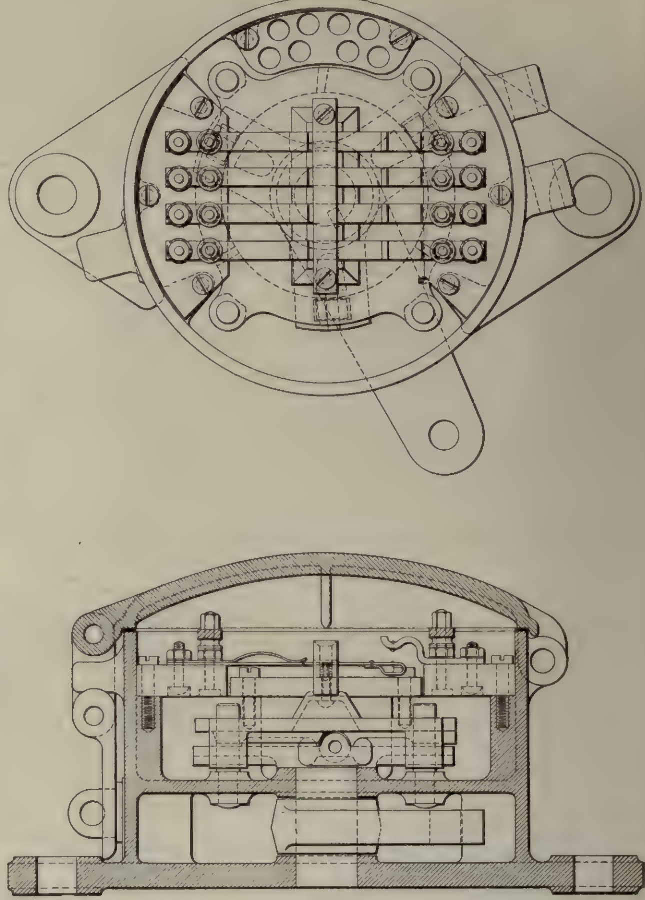
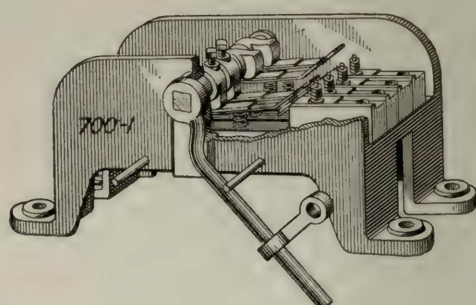


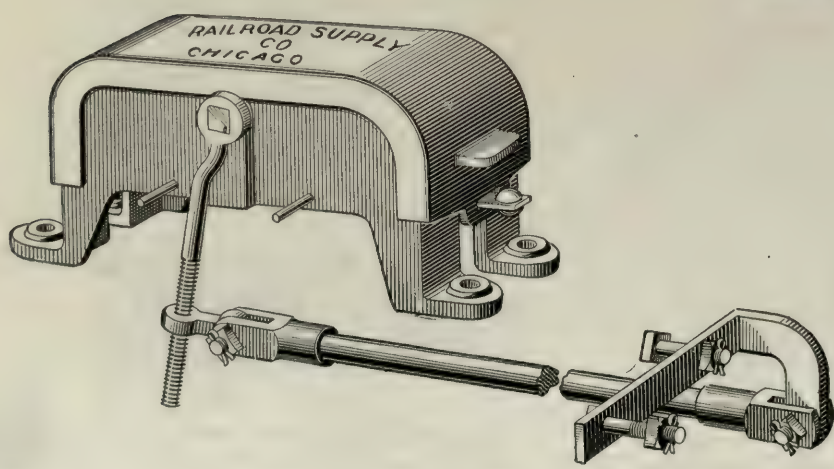
Fig. 2450. Model "B" Switch Box Open. American Railway Signal Company.

Fig. 2451. Switchbox. American Railway Signal Company.

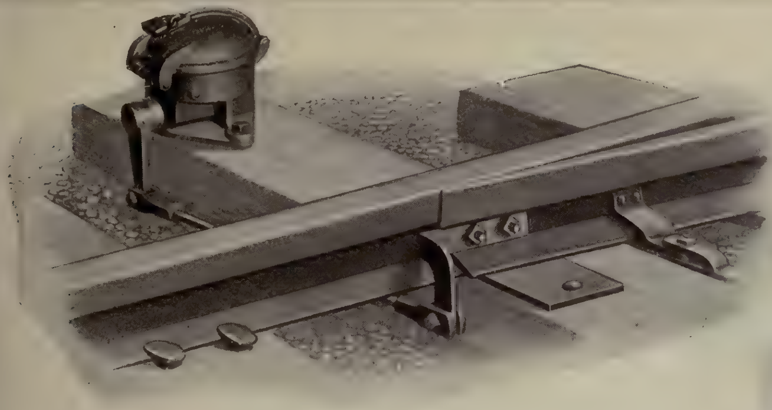


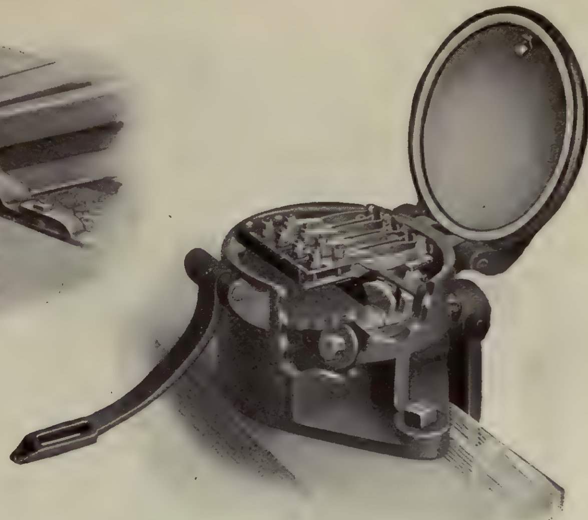
Figs. 2452-2453. Plan and Section of Switchbox. Fig. 2451.



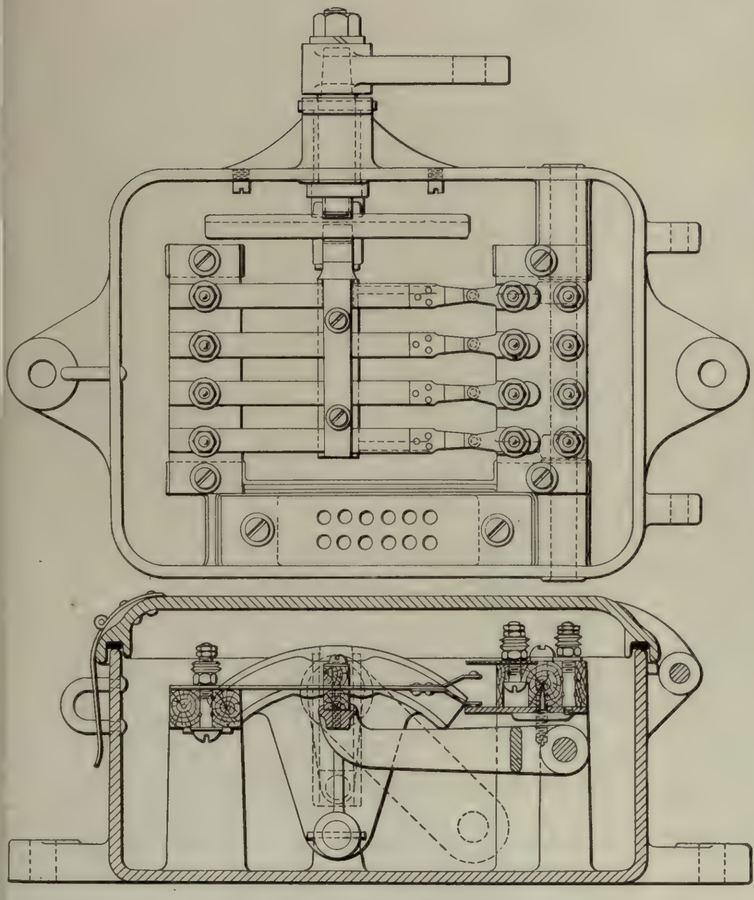


Figs. 2454-2456. Switchbox. Railroad Supply Company.





Figs. 2457-2458. Switchbox. Railroad Supply Company.



Figs. 2459-2461. Shunt Switchbox, with Front and Back Contacts. General Railway Signal Company.

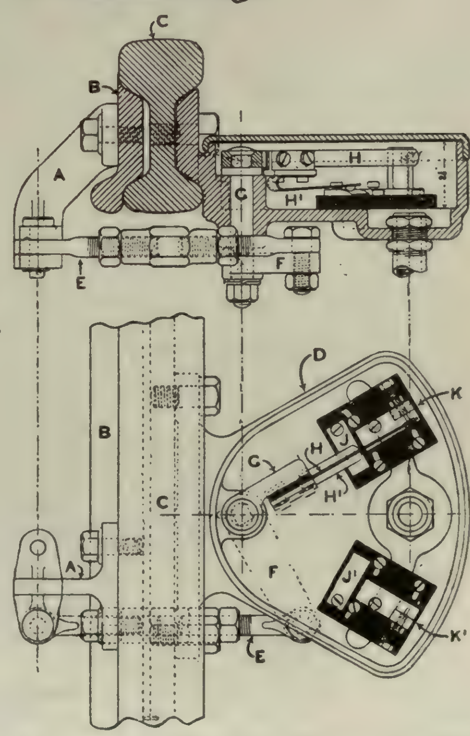


Fig. 2462. Electric Point Detector (Switch-box). W. R. Sykes' Interlocking Company, Ltd., of England.

Names of Parts, Electrical Point Detector; Fig. 2462.

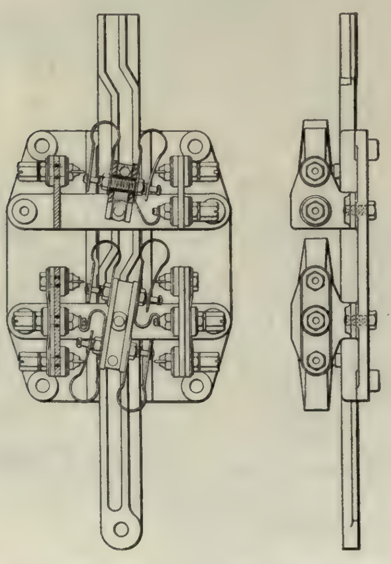
A	*Lug*	F	*Crank Arm*
B	*Switch Point*	G	*Contact Arm and Shaft*
C	*Stock Rail*	H H^1	*Contact Springs*
D	*Case*	J J^1	*Contact Plates*
E	*Operating Rod*	K K^1	*Adjustable Contact Points*

SIGNAL CIRCUIT CONTROLLERS.

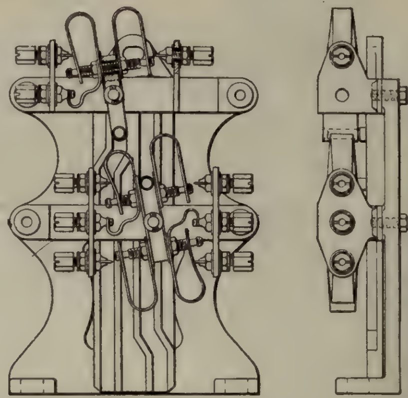
UNION ROTARY CIRCUIT CONTROLLER.

This circuit controller is designed for application to the rear end of the semaphore shafts of mechanical signals. It has two contact springs, which control two independent circuits. These springs are actuated by two cams connected to the semaphore shaft by a bolt and sleeve. The cams have corrugated faces, making it possible to fasten them at any desired angle, so as to operate the contact springs at whatever point in the stroke of the signal may be necessary.

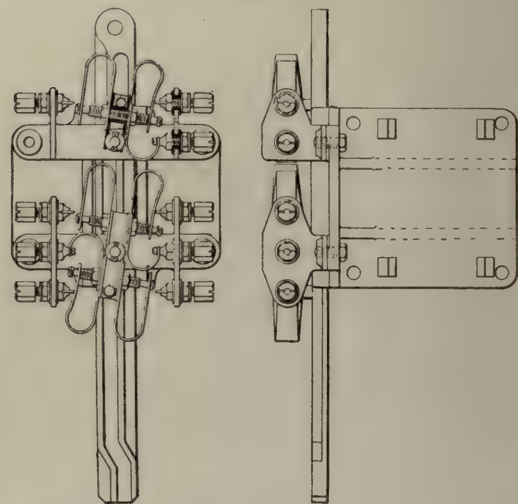
Fig. 2463. Duplex Rotary Circuit Controller. The Union Switch & Signal Company.



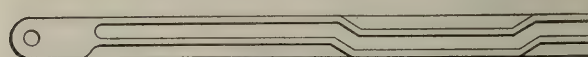
Figs. 2468-2469. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Signal.



Figs. 2464-2465. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Dwarf Slide Signal.



Figs. 2466-2467. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Slide Signal.

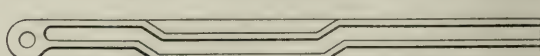


For Circuit Controller, Closing Two Circuits at Clear and one at Stop.

For Circuit Controller, Closing One Circuit at Clear and Two at Stop.

For Combined Pole Changer and Circuit Controller, Opening Circuit When Starting to Clear and Operating Pole Changer at Clear.

For Combined Pole Changer and Circuit Controller for Three Position Signal, Opening Circuit When Starting to Clear.



For Combined Pole Changer and Circuit Controller, Operating Both When Starting to Clear.

Figs. 2470-2474. Circuit Controller Plates for Use with Electro-Pneumatic Signals. The Union Switch & Signal Company.

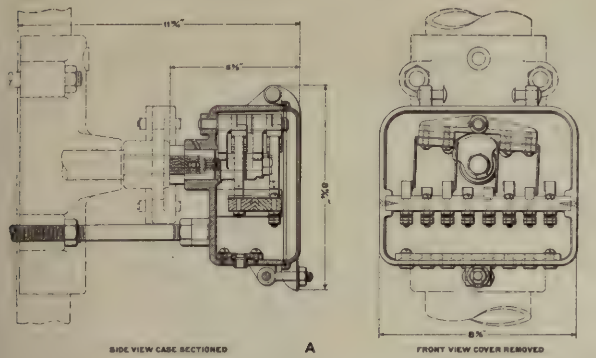


Fig. 2475. Four-Way Circuit Controller for Attaching to Shaft of Mechanical Signals. Union Switch & Signal Company.

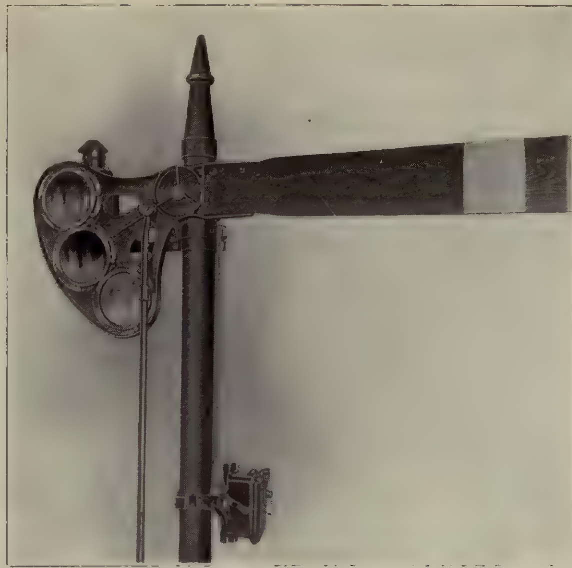


Fig. 2476. Style "E" Commutator Applied to Mechanical Signal. Hall Signal Company.

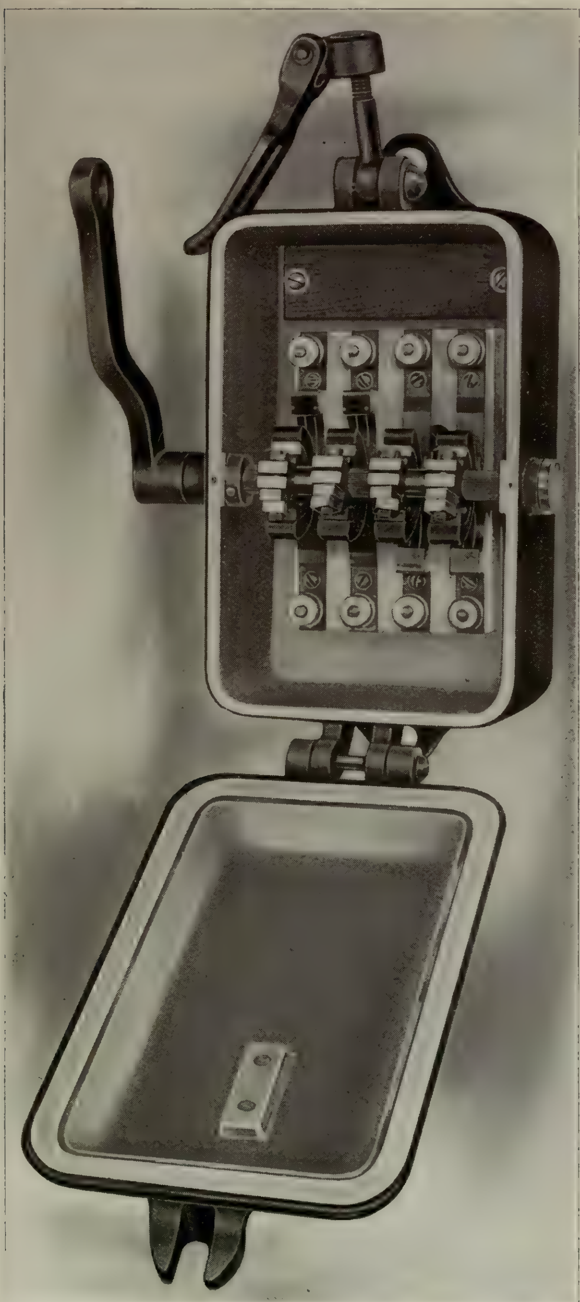


Fig. 2477. Style "E" Commutator, Four-Way. Hall Signal Company.

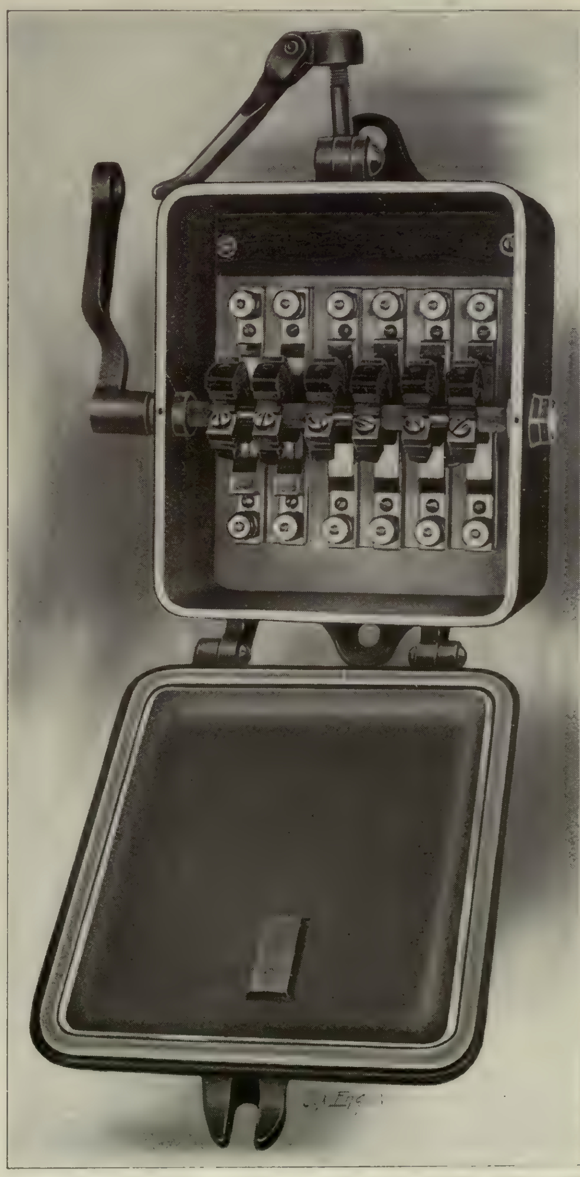


Fig. 2478. Style "E" Commutator Six-Way. Hall Signal Company.

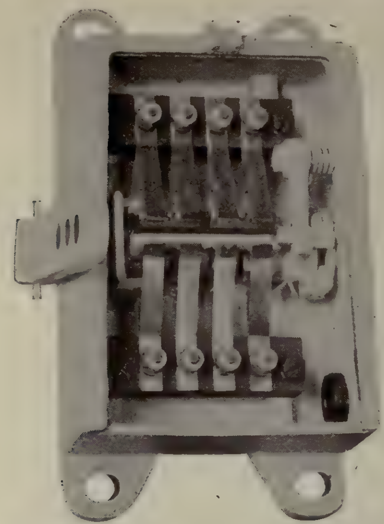
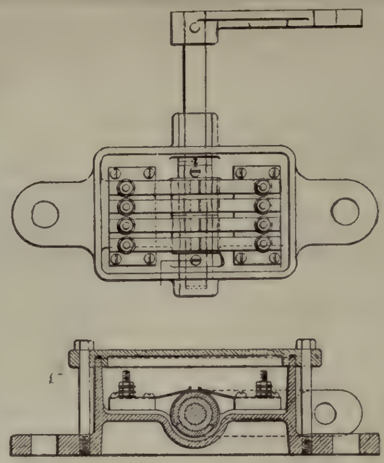
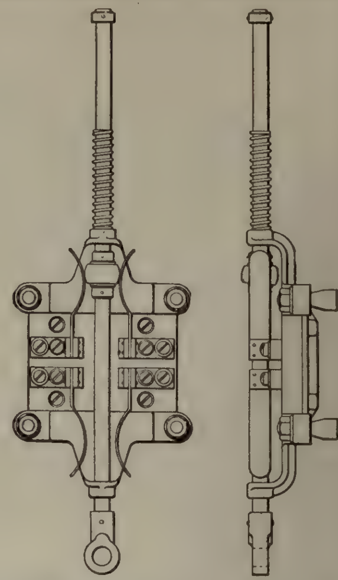


Fig. 2479. Circuit Controller for Signals, Levers, etc. General Railway Signal Company.



Figs. 2480-2481. Circuit Controller, Roller Type for Signals, Levers, etc. General Railway Signal Company.



Figs. 2482-2483. Circuit Controller for Electro-Pneumatic Signals. The Union Switch & Signal Company.

Fig. 2484. Circuit Controller for Signals, Levers, etc. Railroad Supply Company.

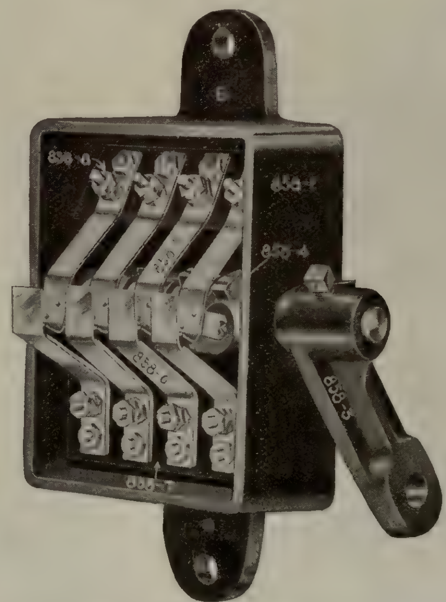


Fig. 2485. Circuit Controller, Fig. 2484 with Cover Removed, Showing Contact Springs Mounted on Slate Block.

Names of Parts, Hall Track Instrument; Figs. 2487-2488.

1, 2 *Terminal Screws*
A *Swinging Arm*
B *Contact Spring*
C *Anvil*
D *Air Chamber*
E *Chamber in Base*
F *Dust Guard and Spring*
G *Large Rubber Spring*
H *Small Rubber Spring*
L *Lever*
R *Valve*
S *Piston and Rod*
X *Air Passage*
Y *Port*

TRACK, TOWER AND BRIDGE CIRCUIT CONTROLLERS.

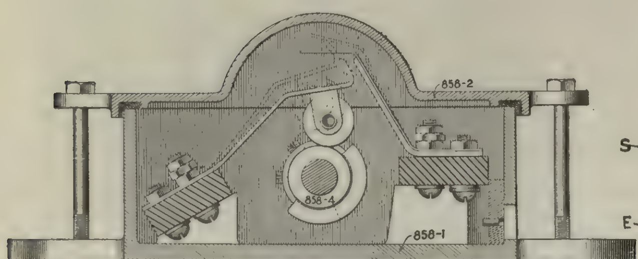
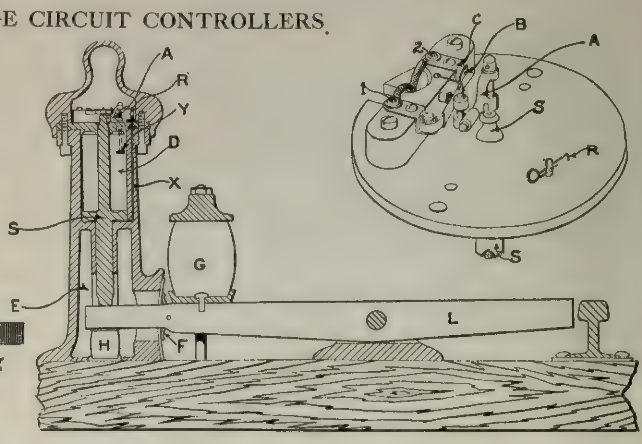


Fig. 2486. Sectional View of Figs. 2484-2485, Showing Operation of Parts.



Figs. 2487-2488. Track Instrument. Hall Signal Company.

HALL TRACK INSTRUMENT.

Figs. 2487-2488 show the track instrument made by the Hall Signal Company. Depression of lever L by the wheels of a train forces piston S upward. This piston moves in an air chamber D, and communicates motion to the swinging arm A of the circuit controlling apparatus.

Upper and lower ends of the air chamber D are connected with each other by an air passage X, and valve R, so arranged that when piston S is forced upward, a portion of the air above the piston is forced out through the port Y through valve R and passage X, to the under side of the piston. Continued raising of the piston covers opening Y, and shuts off communica-

tion between top and bottom of chamber D. The air remaining forms a cushion preventing the piston rod from being thrown forcibly up against the cover. The beveled top of the piston rod extends through the plate on which the contacts are mounted and when raised engages the roller of swinging arm A, forcing spring B into contact with its anvil C, thereby completing a circuit. Air below the piston also acts as a cushion to prevent shocks when the piston falls. R is a valve for regulating the air pressure. Its lower extremity covers the top of the passage X. G and H are rubber springs so compressed that any weight less than that imposed by the pressure of an ordinary car wheel fails to operate the piston. Contact springs can be arranged either normally open as shown, or normally closed, and they can be furnished in multiple for the control of a number of circuits.

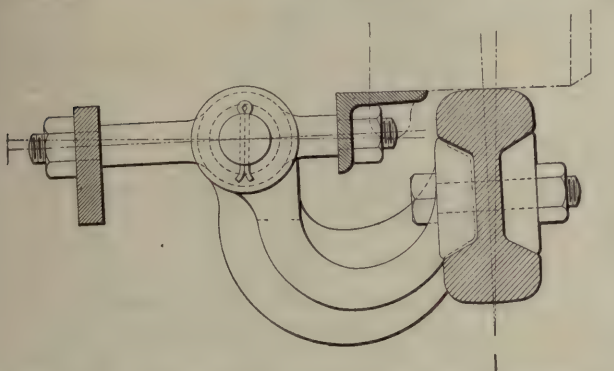
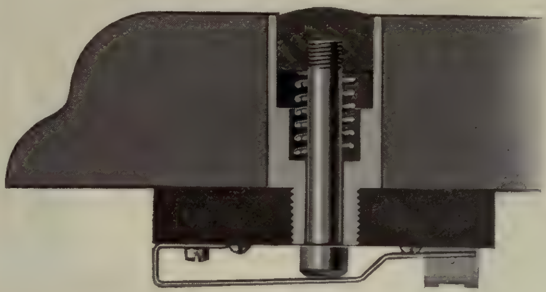


Fig. 2489. Fouling Bar. Great Western Railway of England.

FOULING BAR.

The fouling bar, illustrated in Fig. 2489, is used to operate a circuit controller, thereby locking a switch or signal until the train is off the bar and clear of a certain section of track.



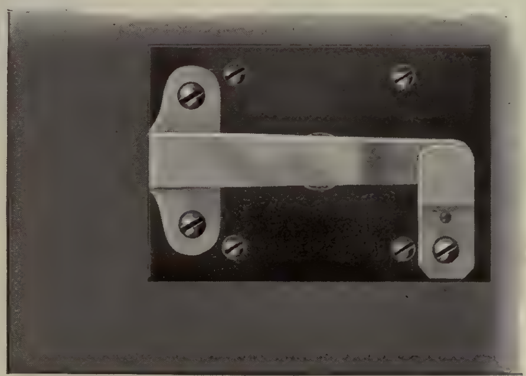
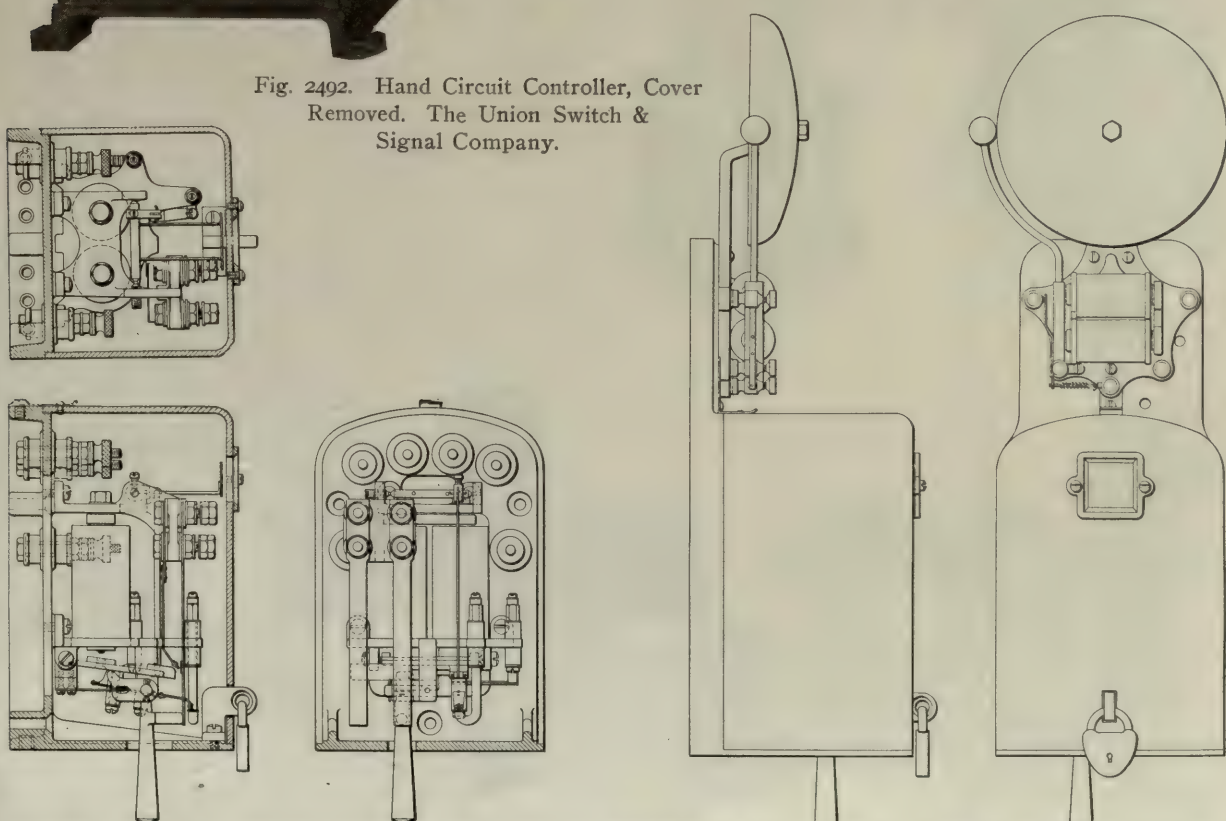


Fig. 2490-2491. Table Circuit Controller. Union Switch & Signal Company.

Fig. 2492. Hand Circuit Controller, Cover Removed. The Union Switch & Signal Company.



Figs. 2493-2497. Magnetic Circuit Controller, With and Without Bell. The Union Switch & Signal Company.

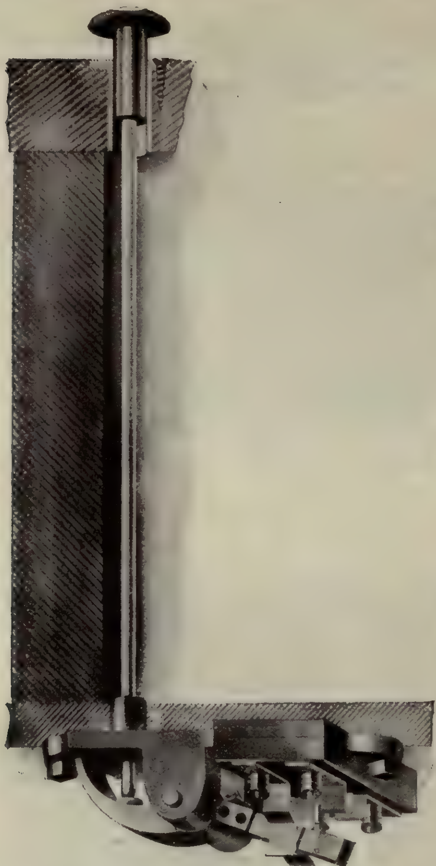


Fig. 2498. Floor Push. Railroad Supply Company.

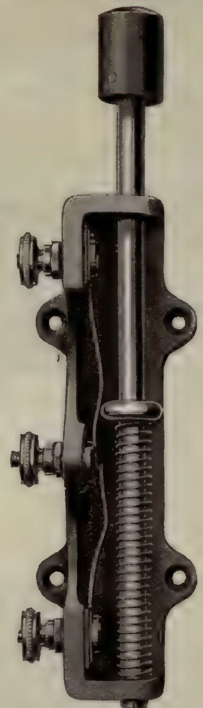
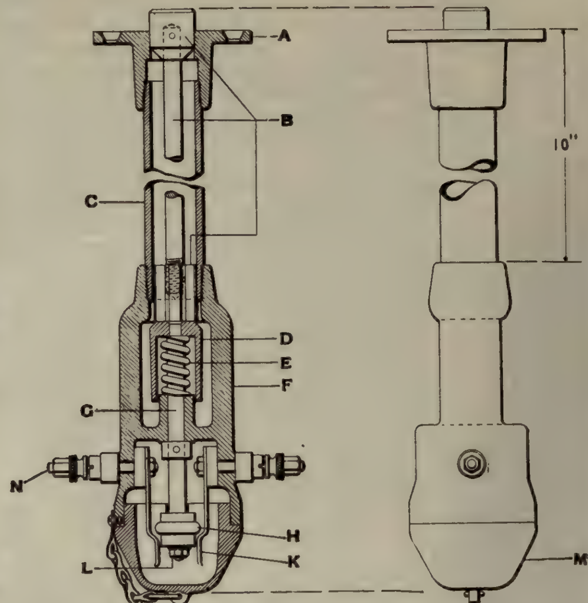


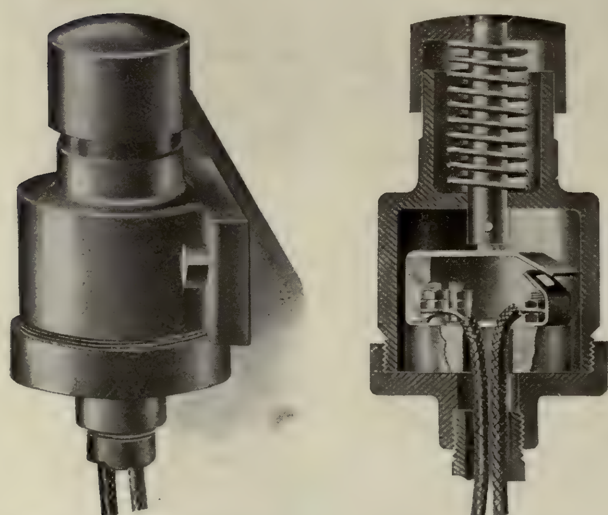
Fig. 2499. Double Circuit Controller for Use with Mechanical Interlocking Machines. Union Switch & Signal Company.



Figs. 2500-2501. Floor Push. General Railway Signal Company.

G. R. S. FLOOR PUSH.

In the floor push shown in Figs. 2500-2501 the circuit is closed by pushing down on the plunger B; this compresses spring E, and brings contact ring H against springs K. Ring H is mounted in an insulating bushing held in place on rod G by the nut L. Shield D is fastened to rod G, and diverts all water and dirt that may enter from above to the cavity in F, thus keeping the contacts clean and free from corroding influences.



Figs. 2502-2503. Weatherproof Floor Push. Railroad Supply Company.

Names of Parts of Floor Push; Figs. 2499-2500.

- A *Floor Socket*
- B *Plunger*
- C 1" *Wrought Iron Pipe*
- D *Shield*
- E *Spring*
- F *Contact Box*
- G *Steel Rod*
- H *Contact Ring*
- K *Contact Spring*
- L *Brass Nut*
- M *Cap*
- N *Binding Post*

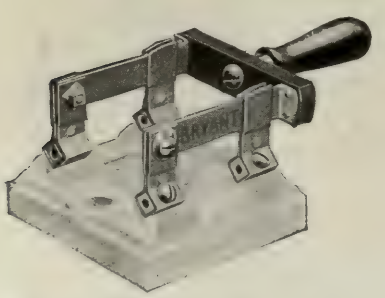


Fig. 2504. Double Pole Single Throw Knife Switch, Porcelain Base.

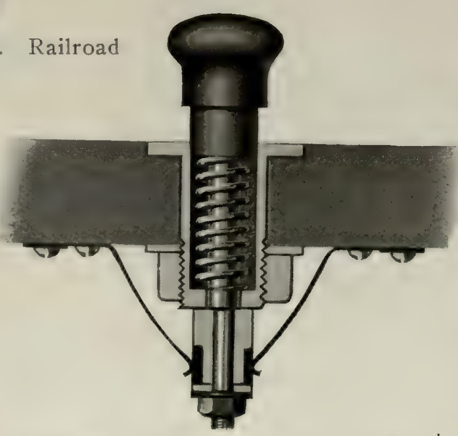


Fig. 2505. Table Push. The Union Switch & Signal Company.

Fig. 2506. Single Circuit Controller for Use with Mechanical Interlocking Machine. The Union Switch & Signal Company.

FLOOR PUSH.

The Hall floor push is shown in Fig. 2507. The circuit is closed by pressing on plunger P, the movement of which compresses spring S, forcing circular contact C against spring D.

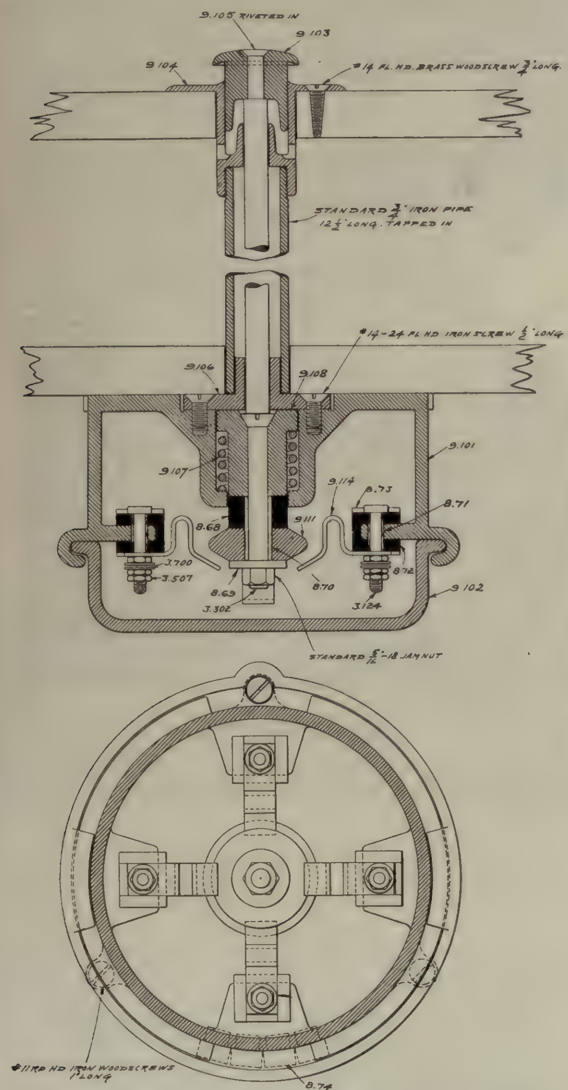


Fig. 2507. Floor Push Complete. Hall Signal Company.

When the pressure is removed, plunger P, by action of spring S, rises to its normal position. The projecting head of the plunger and the provision for drainage at bushing M prevent the access of dirt and water.

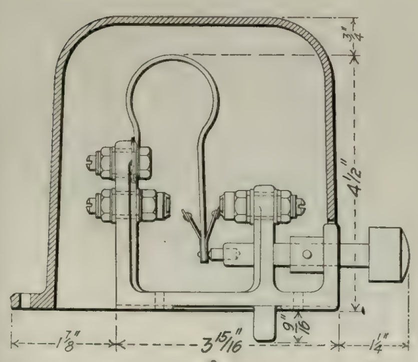


Fig. 2513. Bell Key in Case. The Union Switch & Signal Company.

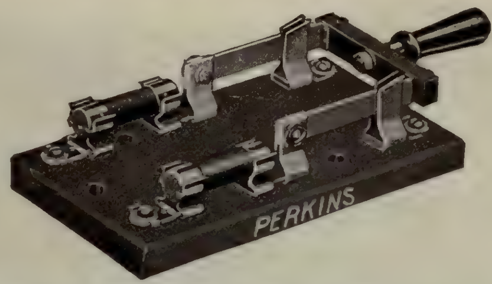


Fig. 2508. Double Pole Single Throw Knife Switch with Cartridge Fuse Protection, Slate Base.

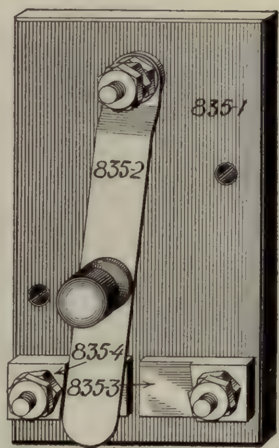


Fig. 2509. Two-Point Switch, Slate Base. Railroad Supply Company.

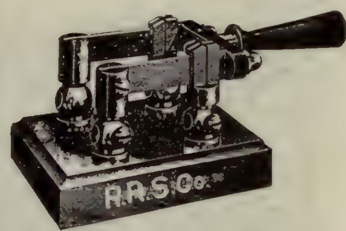


Fig. 2510. Double Pole Single Throw Knife Switch Porcelain Base. Railroad Supply Company.

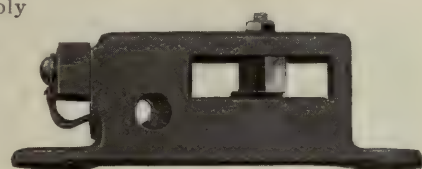


Fig. 2511. Cam Circuit Controller. The Union Switch & Signal Company.

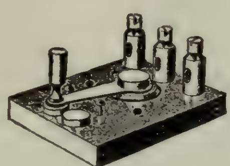


Fig. 2512. Two-Point Switch, Hard Rubber Base.

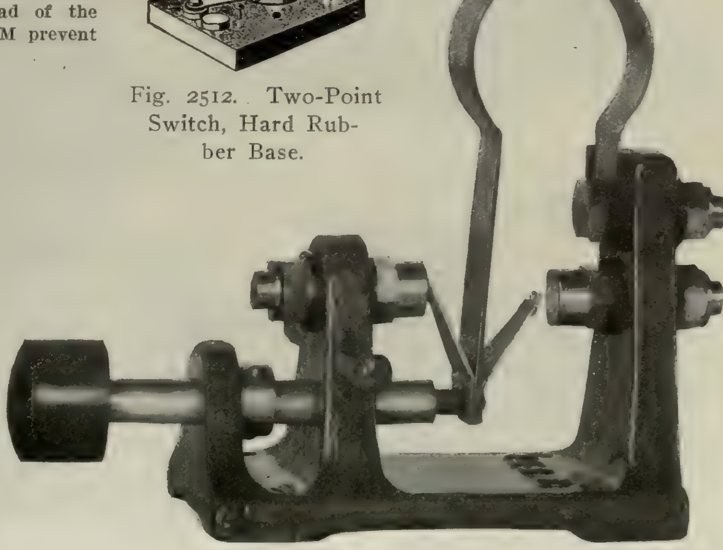
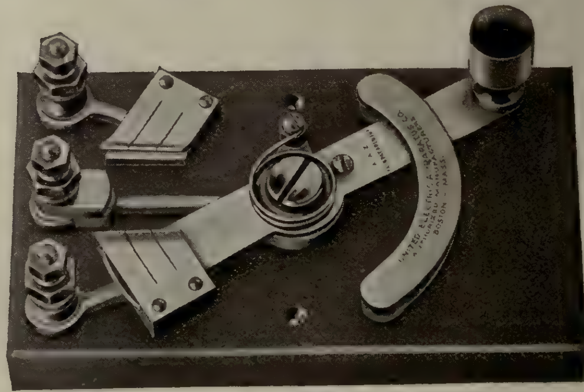


Fig. 2514. Bell Key, Fig. 2513.

Two Contact Strap Key.

Single Contact Strap Key.

Single Point Switch.



Two-Point Switch.

Figs. 2524-2527. Switches. United Electric Apparatus Company.

IRON CLAD SWITCH.

This switch is designed for use in connection with electric switch locks where a number of switches are controlled from one central point. It is arranged so that only one electric lock can be unlocked at a time, thus preventing more than one train entering the main track. Made with from two to six points. Size: five inches square, three inches high.

STRAP KEY.

Fig. 2530 illustrates a type of strap key manufactured by the Bryant Zinc Co. This key has heavy binding posts and is equipped with upper and lower platinum contacts. It is so arranged that it can be used for open or closed circuit or both. An adjustment screw regulates the travel of the lever to suit the operator.

Figs. 2528-2529. Iron Clad Switch. Bryant Zinc Company.

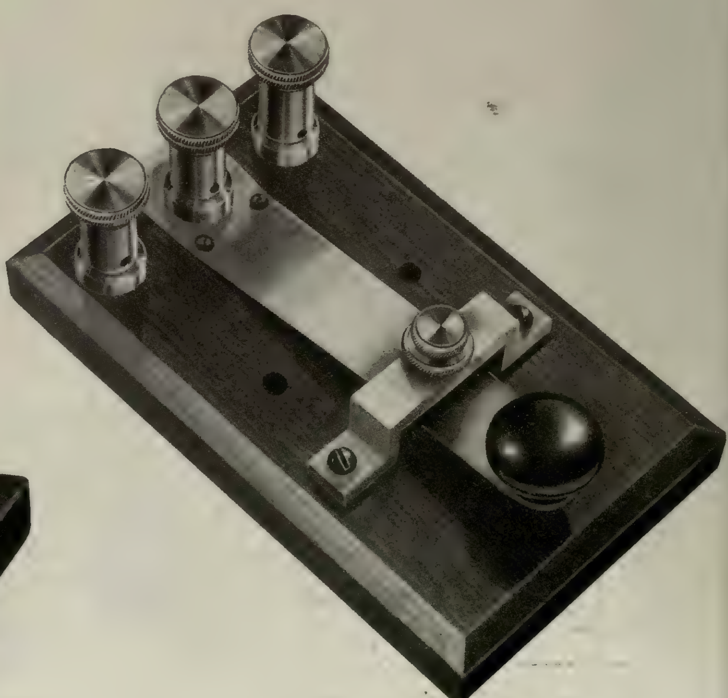


Fig. 2530. Strap Key. Bryant Zinc Company.

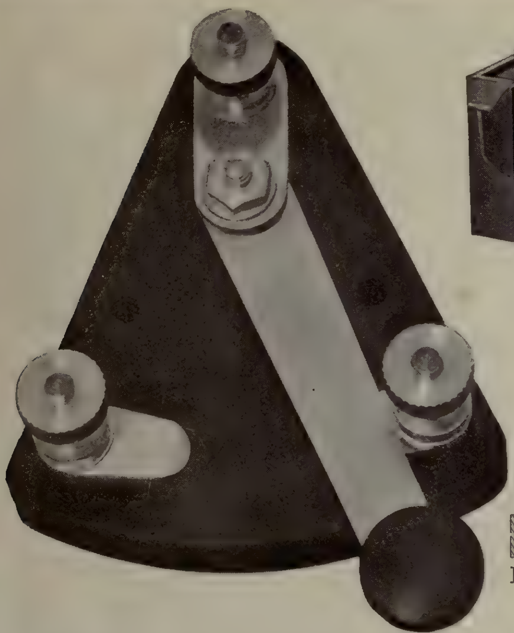


Fig. 2531. Two-Point Switch.

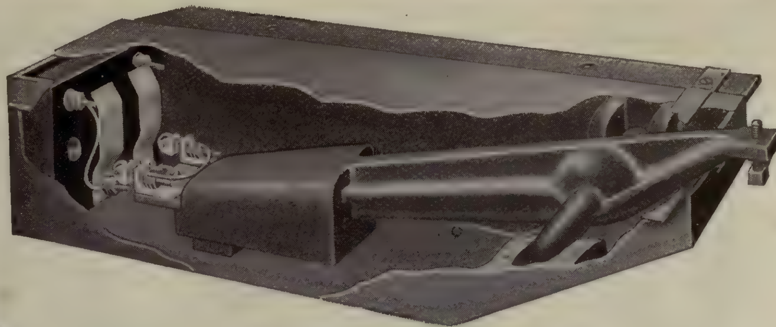


Fig. 2532. Track Instrument. Railroad Supply Company.

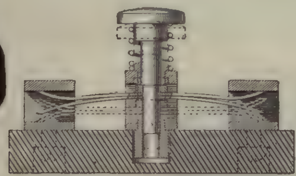


Fig. 2533. Sectional View of Fig. 2534. Showing Operation of Key.

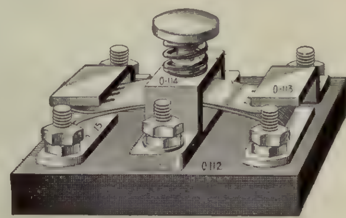
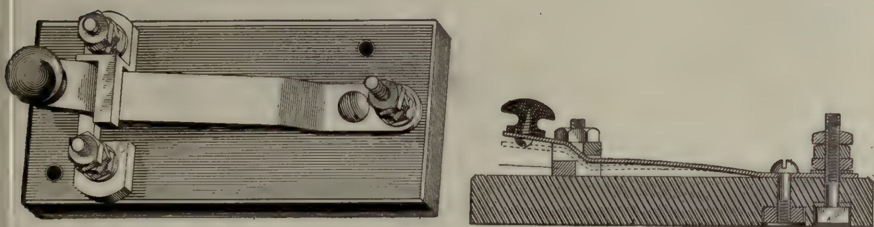


Fig. 2534. Push Key. Railroad Supply Company.



Figs. 2535-2536. Strap Key. Railroad Supply Company.

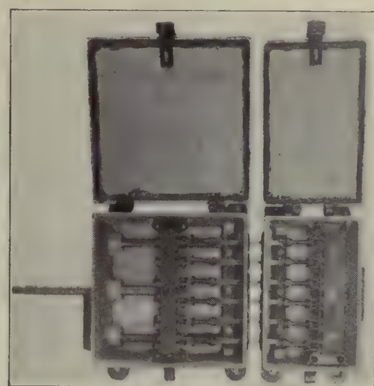


Fig. 2537. Six-Way Bridge Circuit Controller. American Railway Signal Company.

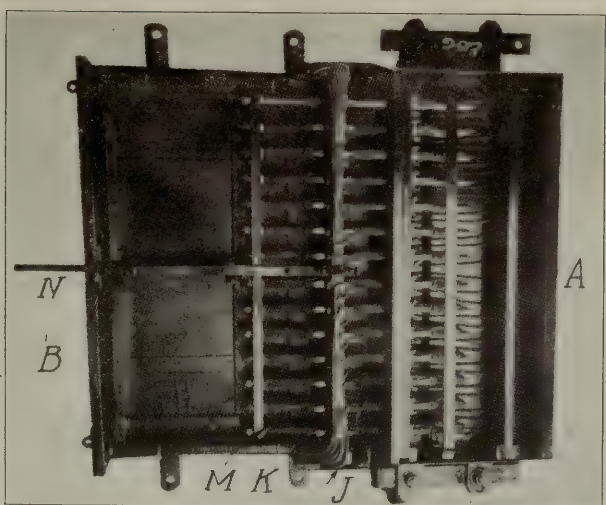


Fig. 2538. Plan View of Style "C" Drawbridge Circuit Controller. T. George Stiles Company.

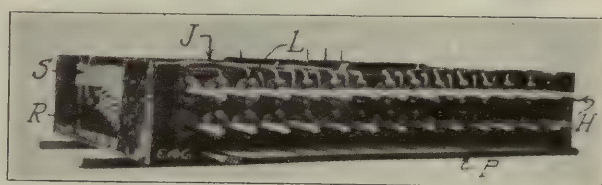


Fig. 2539. Elevation of Front and Side of Bridge Member. T. George Stiles Company.

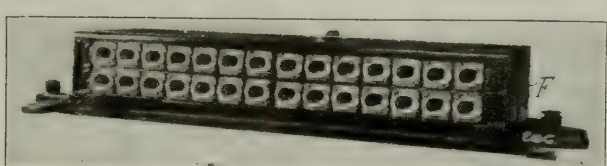


Fig. 2540. Front Elevation of Abutment Member. T. George Stiles Company.

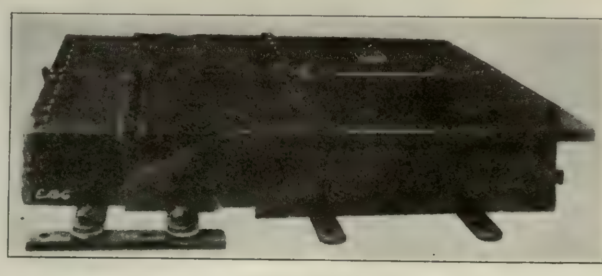


Fig. 2541. Side View of Circuit Controller Coupled. T. George Stiles Company.

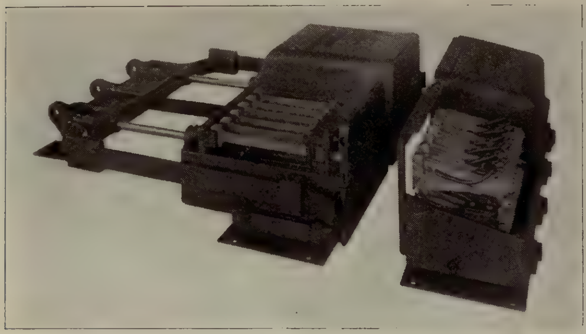


Fig. 2542. Drawbridge Circuit Closer (24-Way) with Centering Device. Slide Withdrawn.

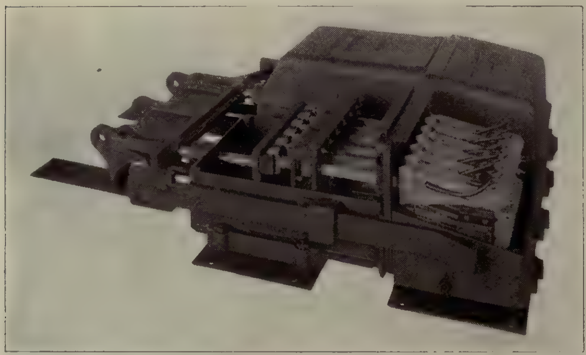


Fig. 2543. Drawbridge Circuit Closer (24-Way) with Centering Device. Contacts Closed.

Fig. 2544. Drawbridge Circuit Closed (12-Way) with Centering Device. Contacts Closed.

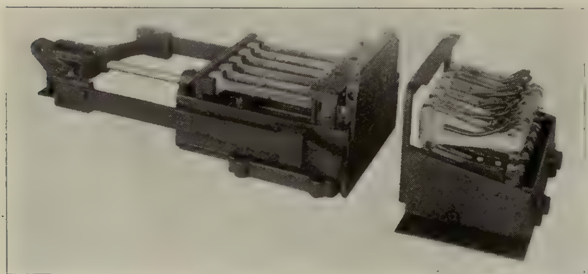


Fig. 2545. Drawbridge Circuit Closer (12-Way) with Centering Device. Slide Withdrawn.

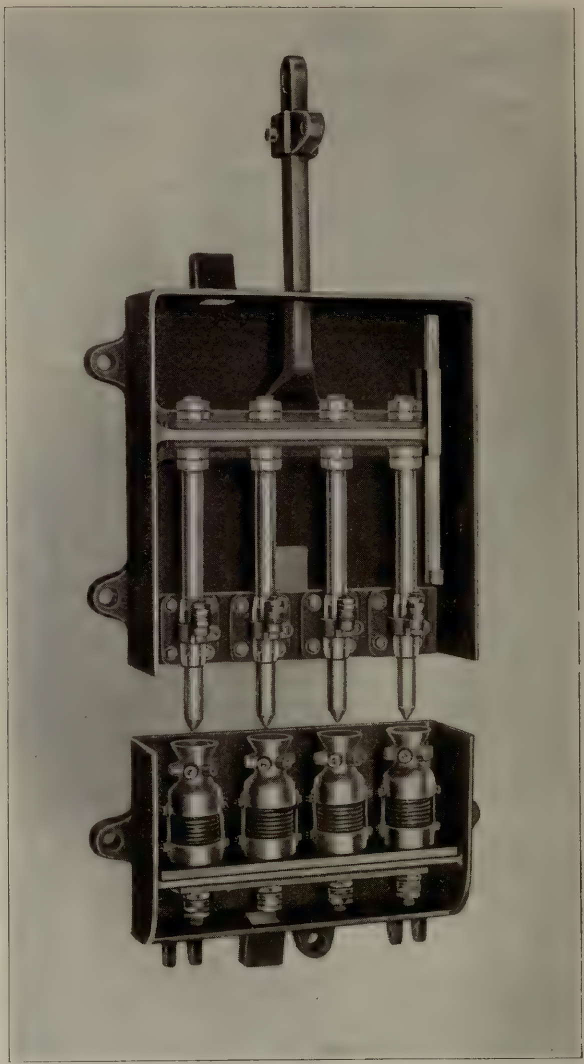
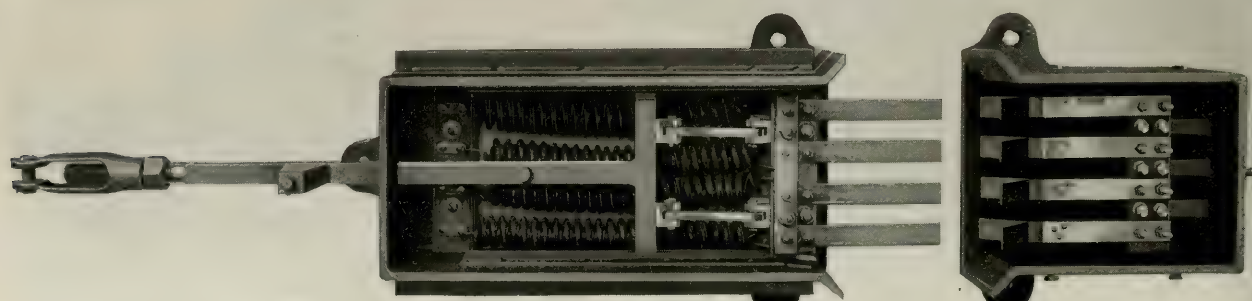


Fig. 2546. Drawbridge Circuit Controller with Cover Removed. Hall Signal Company.

Fig. 2547. Drawbridge Circuit Controller Covered. Hall Signal Company.

Figs. 2542-2545 show Drawbridge Circuit Controllers Made by the General Railway Signal Company.



Figs. 2548-2549. Electric Bridge Coupler. The Union Switch & Signal Company.

INDICATORS

ANNUNCIATORS AND TOWER INDICATORS

Fig. 2550. Group of Annunciators and Semaphore Indicators. Union Switch & Signal Company.

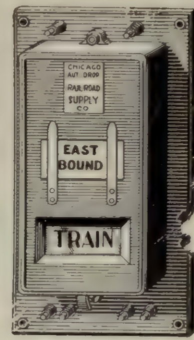
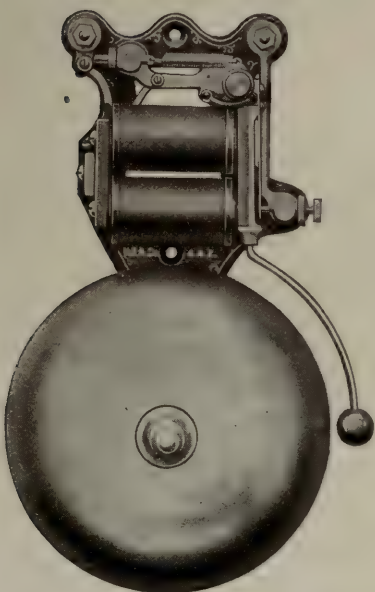


Fig. 2551. Drop Annunciator. Railroad Supply Company.



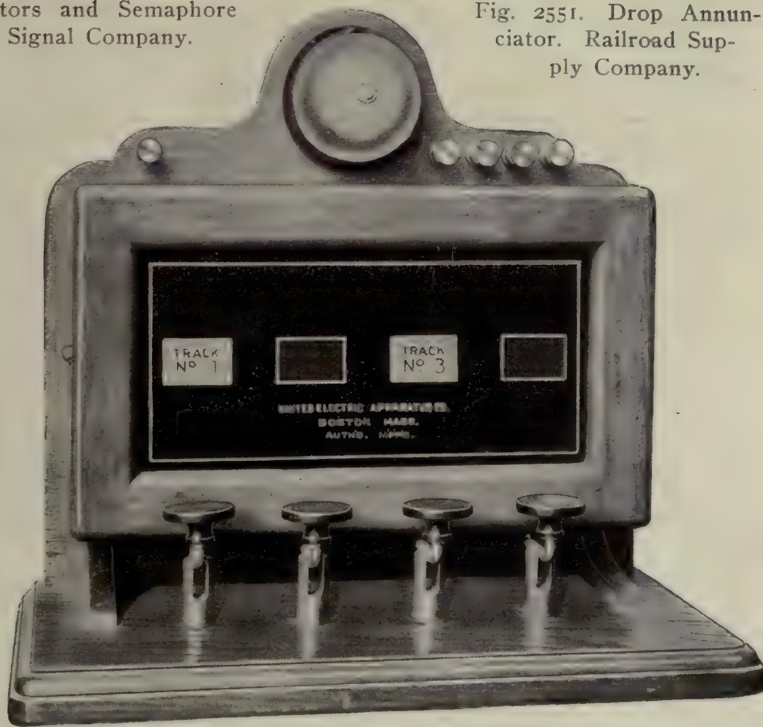


Fig. 2552. Drop Annunciator. United Electric Apparatus Company.

Figs. 2553-2554. Open and Enclosed Types Tower Bells. United Electric Apparatus Company.

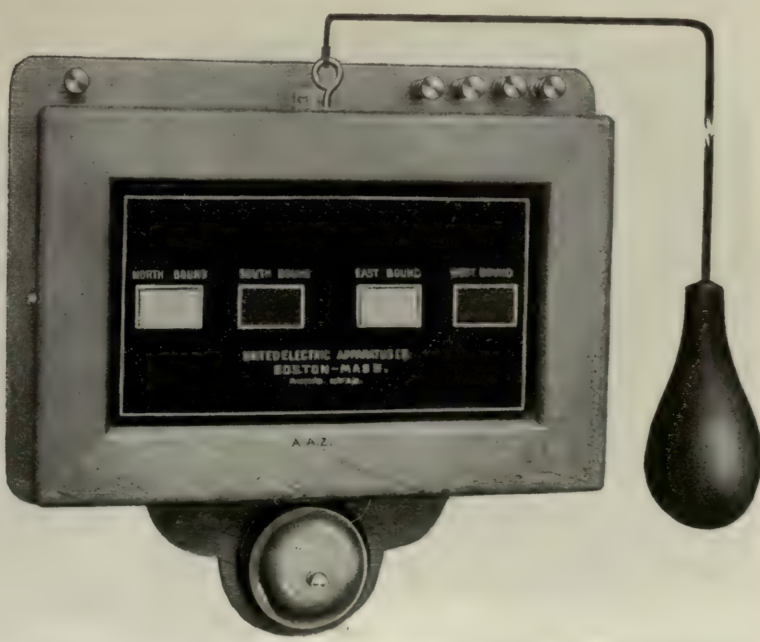


Fig. 2555. Annunciator with Pulley Attachment for Resetting. United Electric Apparatus Company.

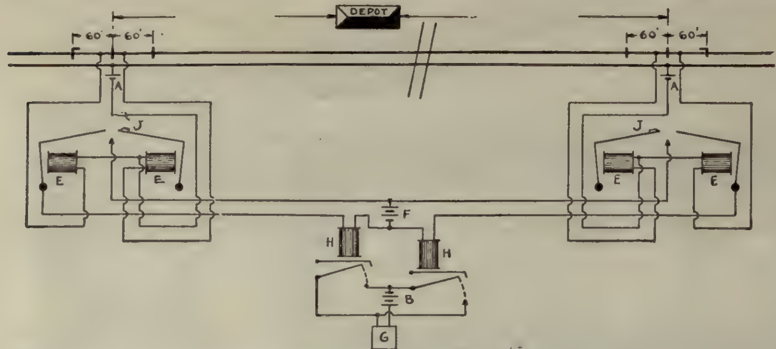


Fig. 2556. Installation with Open Circuit Relays and Open Circuit Annunciators.

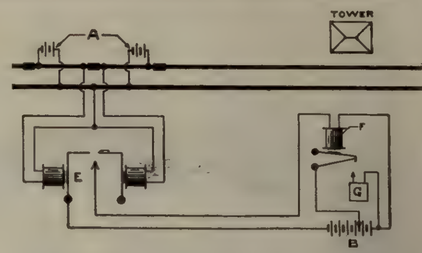


Fig. 2557. Circuits for Drop Annunciator, with Interlocking Relay on Single Track; Automatically Announces Trains, in One Direction Only; Normally Closed Track Circuits. Railroad Supply Company.

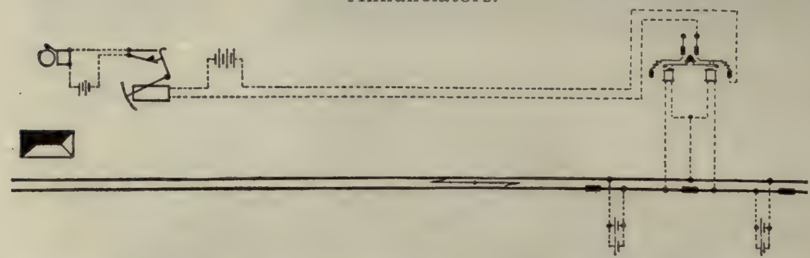


Fig. 2558. Circuit for Drop Annunciator with Interlocking Relay on Single Track; Automatically Announces Train in One Direction Only; Normally Closed Track Circuits. Union Switch & Signal Company.

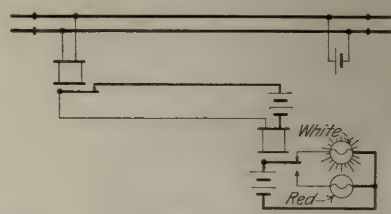


Fig. 2559. Simple Circuit for Track Indicator.

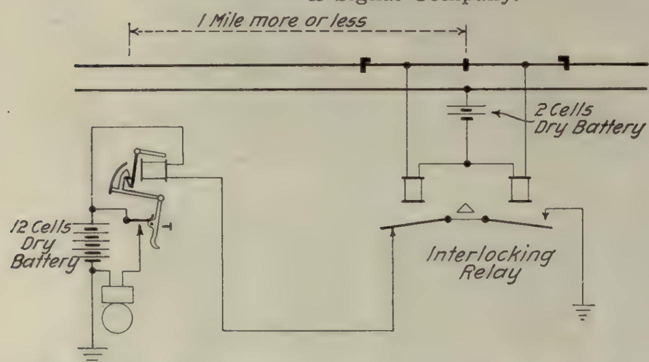


Fig. 2560. Circuit for Drop Annunciator for Use on Single Track; Automatically Announces Trains in One Direction Only; Normally Open Track Circuits.

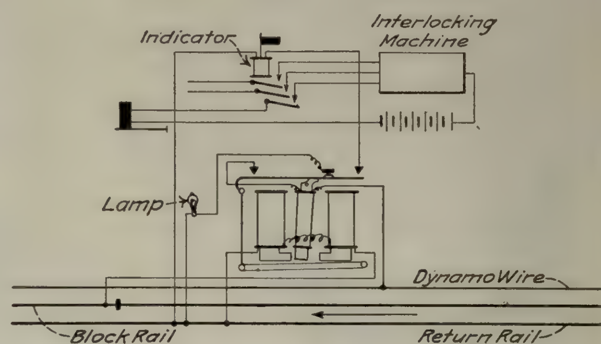
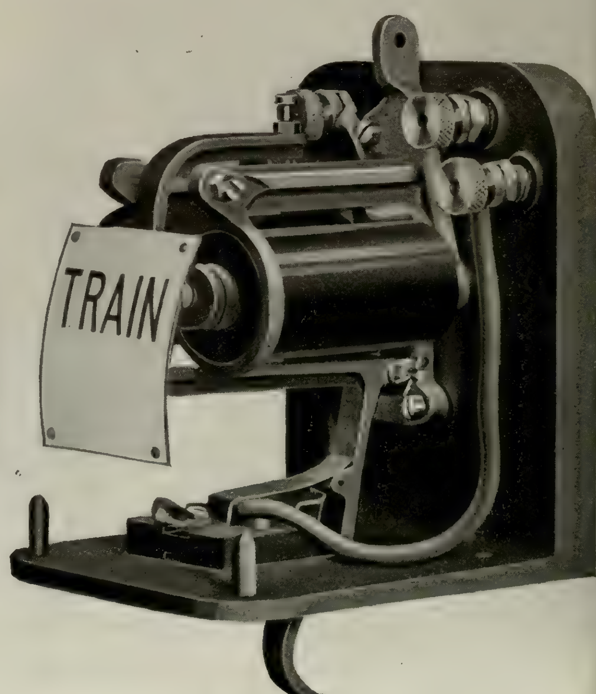
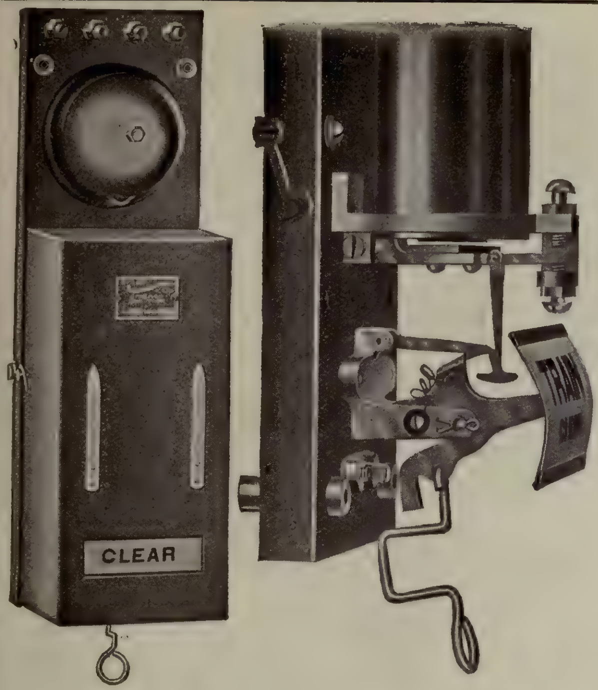


Fig. 2561. Circuits for Block Indicator and Signal at Interlocking Plant. Boston Elevated Railroad.



Figs. 2562-2563. Iron Case Drop Annunciator. Union Switch & Signal Company.



Figs. 2564-2565. Everett Annunciator. Railroad Supply Company.

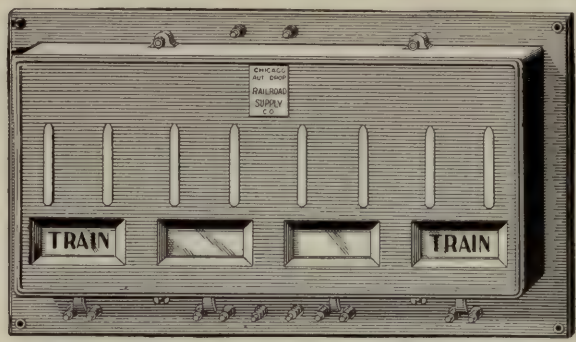


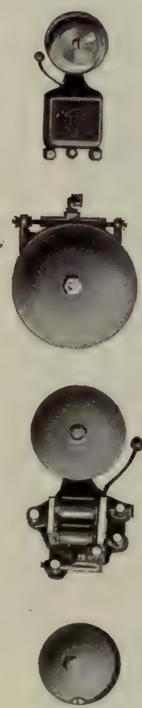
Fig. 2566. Drop Annunciator Group. Railroad Supply Company.

The train annunciator shown in Fig. 2571 is made by the Bryant Zinc Co. This is a compact instrument of the unit type, with iron cover. The size, 4 in. by 4 in. by 11 in., permits placing between tower windows. This annunciator is designed to be used where it is desired to silence the bell while the train is still in the tripping section.

The feature of stopping the bell or buzzer with the train in the tripping circuit obviates the danger of towermen plugging the annunciator to silence the bell or buzzer when there is a long train in the circuit. To silence the bell it is only necessary to raise the banner to the upper position, at which point it will remain until the train leaves the tripping circuit, when it will automatically restore itself and be ready for the next approaching train.

The possibility of the banner being released by vibration has been eliminated by means of a simple device which holds the armature under the banner until the coil is energized, at which time the vibration stop does not affect the movement of the armature. The annunciators are furnished with either a mechanical restoring rod or an electrical resetting coil, by means of which the banner can be reset from any part of the tower through a push button.

Platinum to platinum contacts are furnished. The annunciators are mounted on a polished hardwood base and are protected by a neat enameled iron case. The standard winding is 25 ohms.



Figs. 2567-2568. Types of Electric Bells Used With Annunciators and Indicators or Separately.

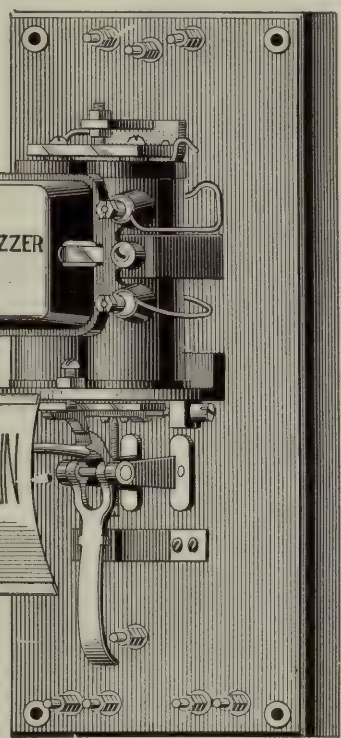


Fig. 2569. Mechanism of Drop Annunciator. Railroad Supply Company.

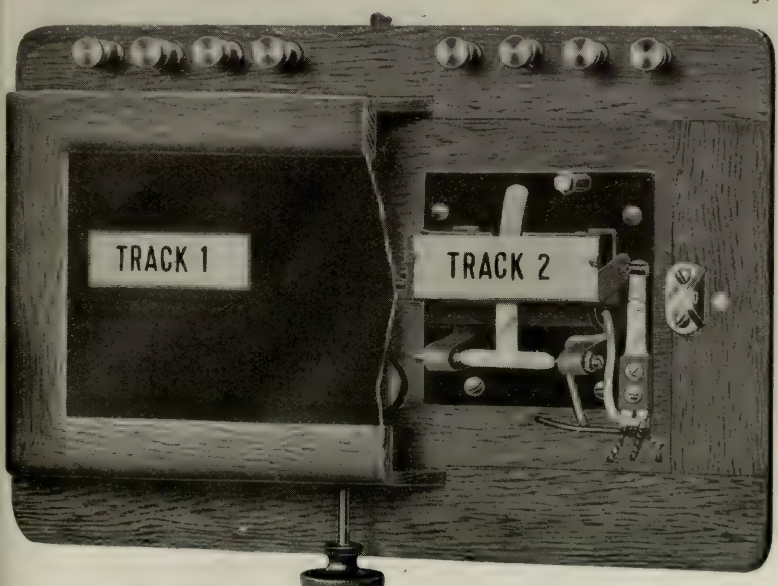


Fig. 2570. Drop Annunciator. Bryant Zinc Company.

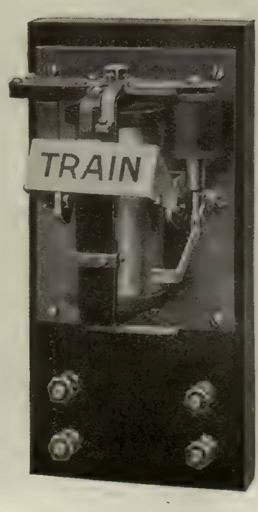


Fig. 2571. Train Annunciator. Bryant Zinc Company.

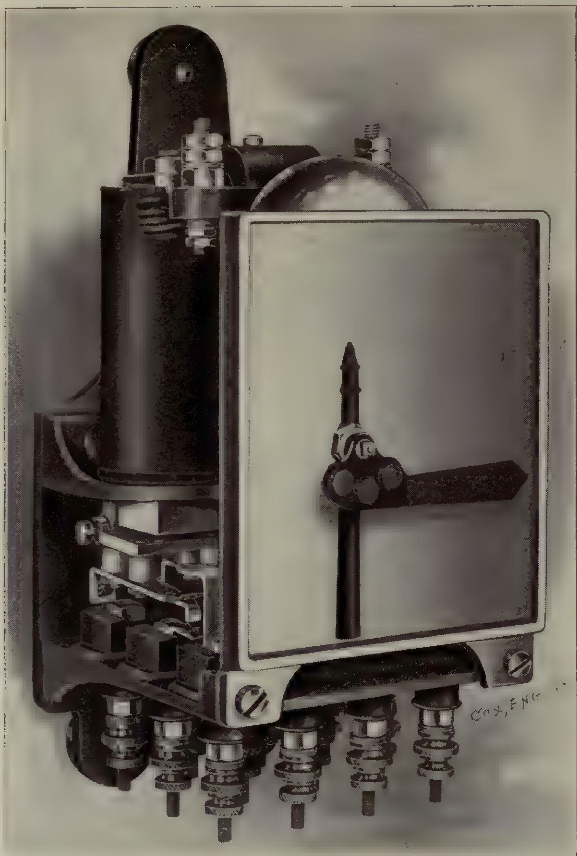
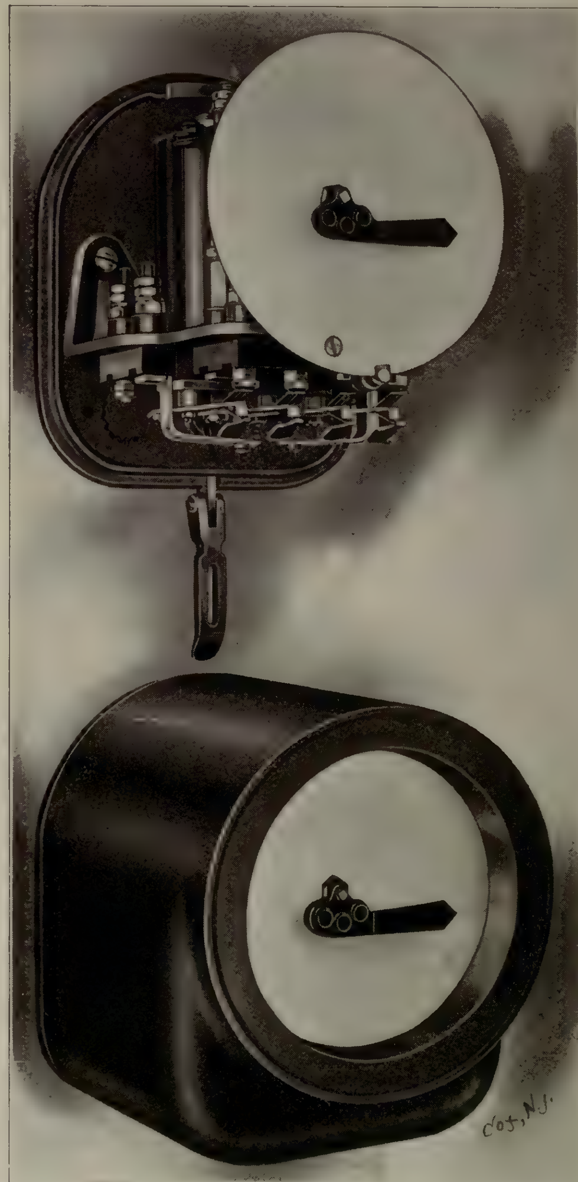


Fig. 2572. Tower Indicator Semaphore Type. Hall Signal Company.



Figs. 2574-2575. Style "C" Tower Indicator. Hall Signal Company.

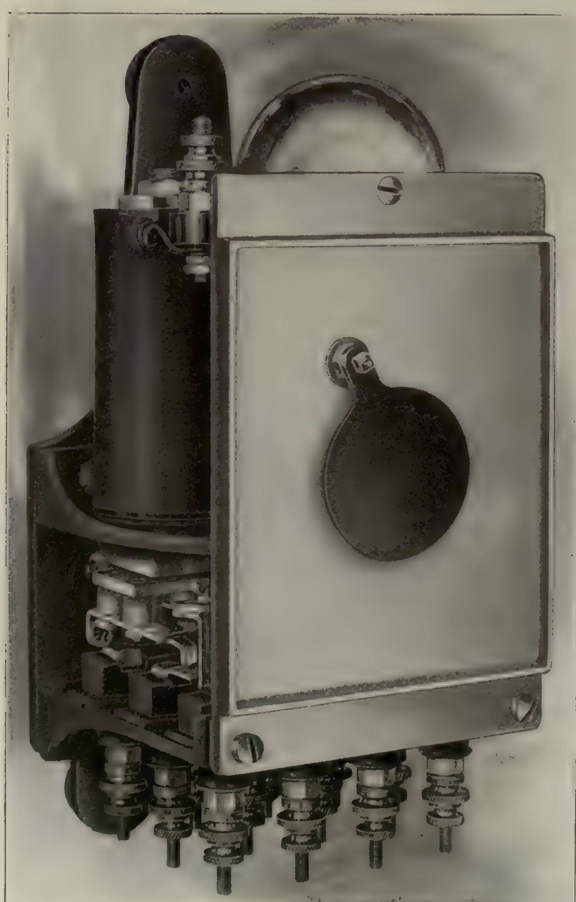


Fig. 2573. Tower Indicator Disc Type. Hall Signal Company.

Fig. 2576. Indicator Case Three-Way. Hall Signal Company.

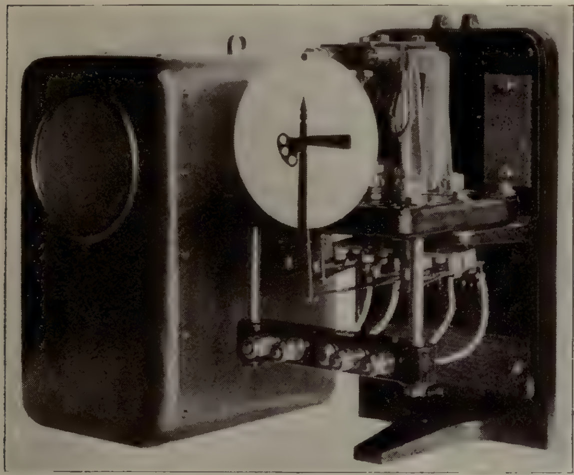


Fig. 2577. A. C. Tower Indicator. The Union Switch & Signal Company.

UNION TOWER INDICATOR.

The Union tower indicator illustrated in Figs. 2577-2578 has form-wound coils and makes use of 9-C relay parts wherever possible. The parts are mounted on a porcelain base in the

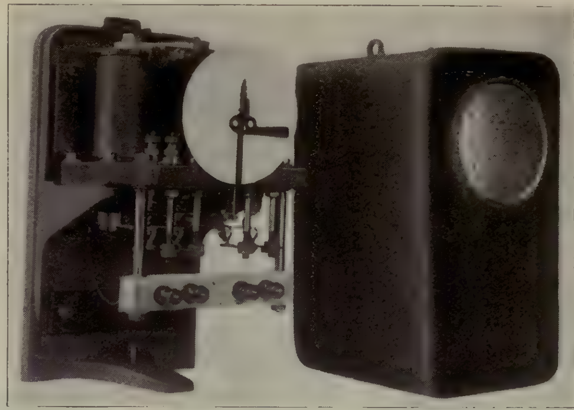
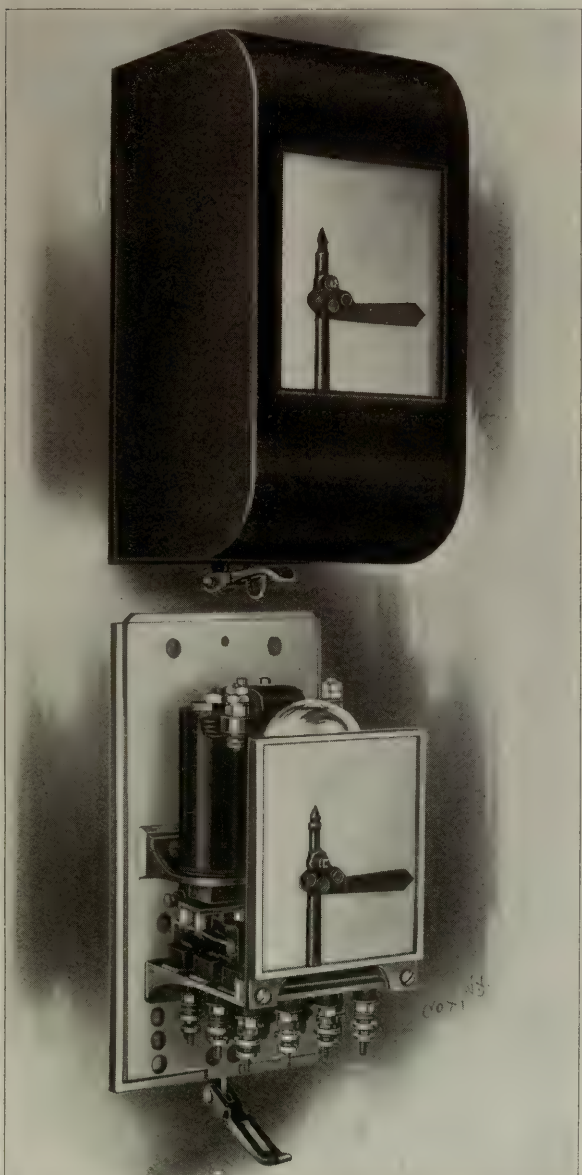
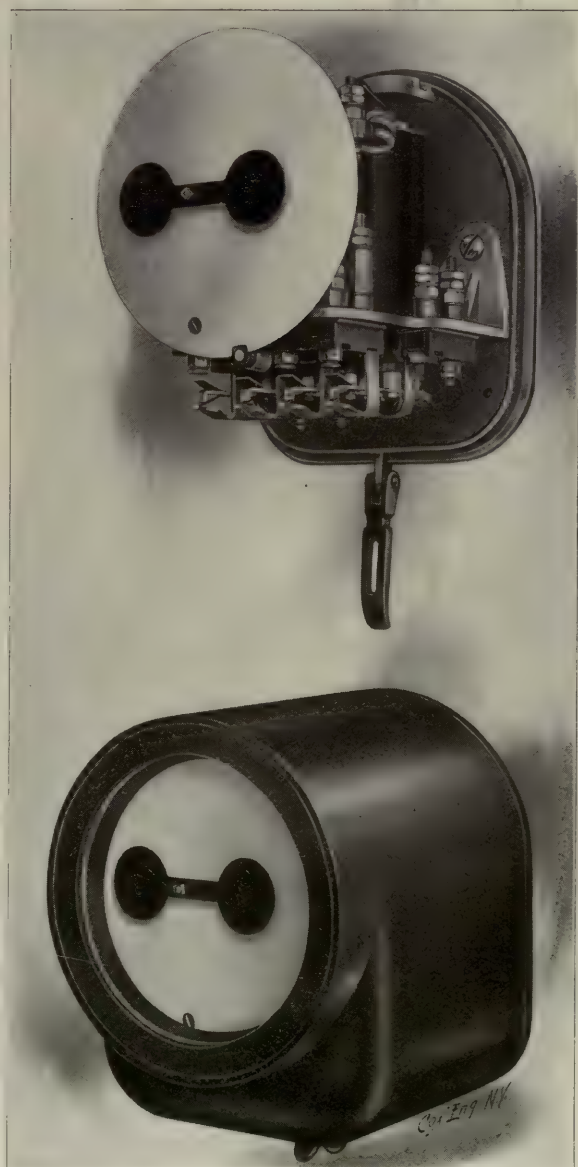


Fig. 2578. D. C. Tower Indicator. The Union Switch & Signal Company.

same manner as in the relay. The flexible connections at the rear of the contact springs are unusually long and are brought forward to porcelain terminal strip. All of the terminal posts are very accessible. When the cover is removed all of the parts are in plain view and easy of inspection. The mechanism is universal in that it may be operated by d. c. magnets or by the a. c. jaw type magnet.



Figs. 2579-2580. Indicator with Cover. Hall Signal Company.



Figs. 2581-2582. Style "C" Disc Tower Indicator. Hall Signal Company.

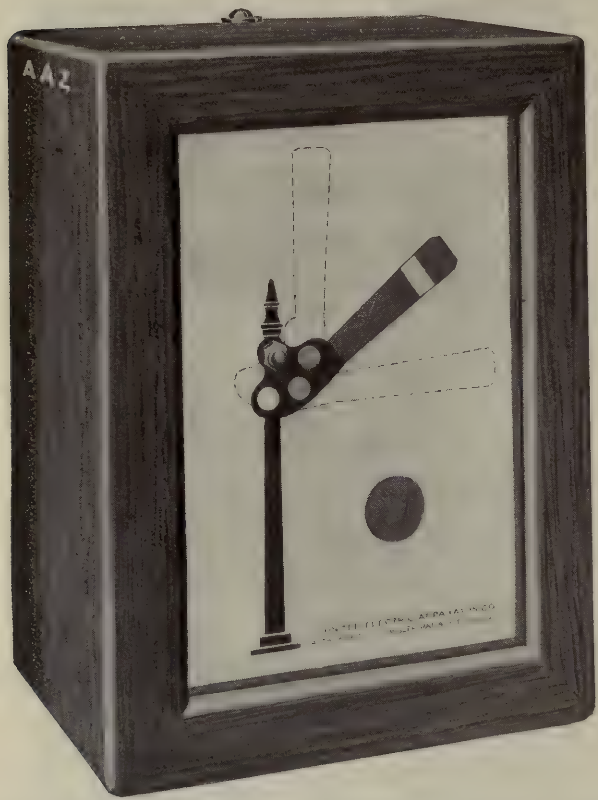


Fig. 2583. Upper Quadrant Semaphore Indicator with "Out of Order" Disc. United Electric Apparatus Company.

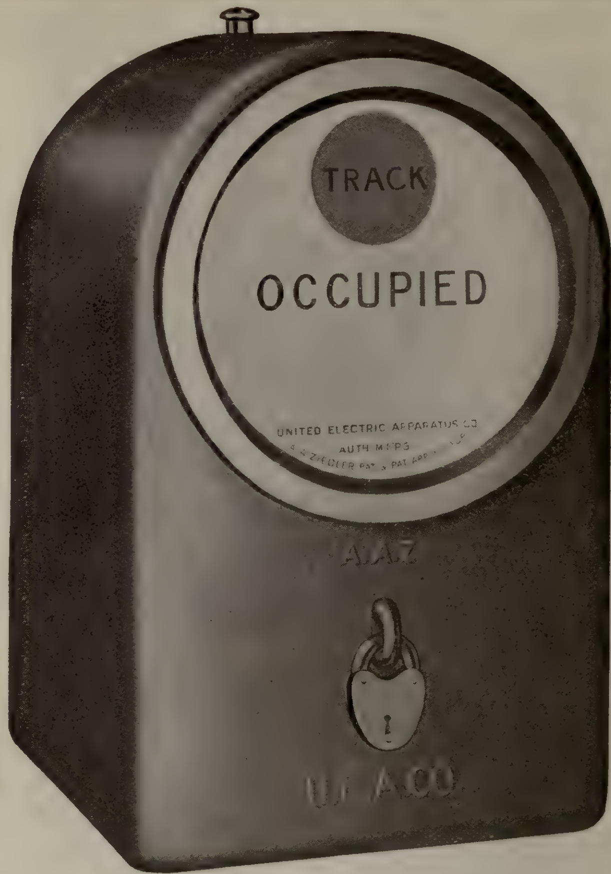


Fig. 2584. Disc Indicator A. C. or D. C. with Iron Case. United Electric Apparatus Company.

Fig. 2585. Upper Quadrant Semaphore Indicator A. C. or D. C. United Electric Apparatus Company.

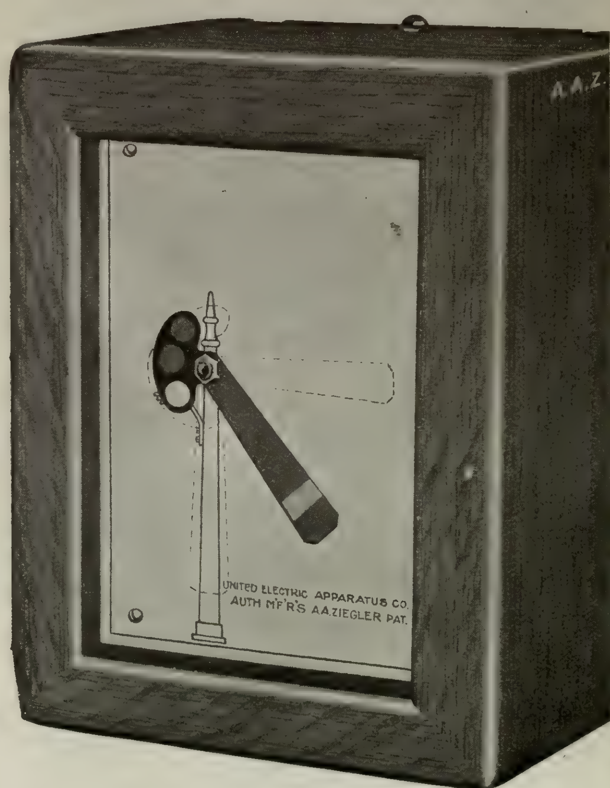


Fig. 2586. Lower Quadrant Semaphore Indicator. United Electric Apparatus Company.

Figs. 2587-2588. Group of Indicators in Wooden Case. Railroad Supply Company.

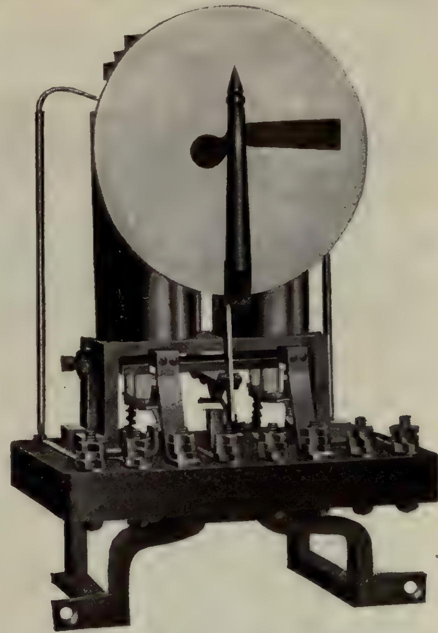


Fig. 2589. Style "A" Indicator Mechanism. Railroad Supply Company.

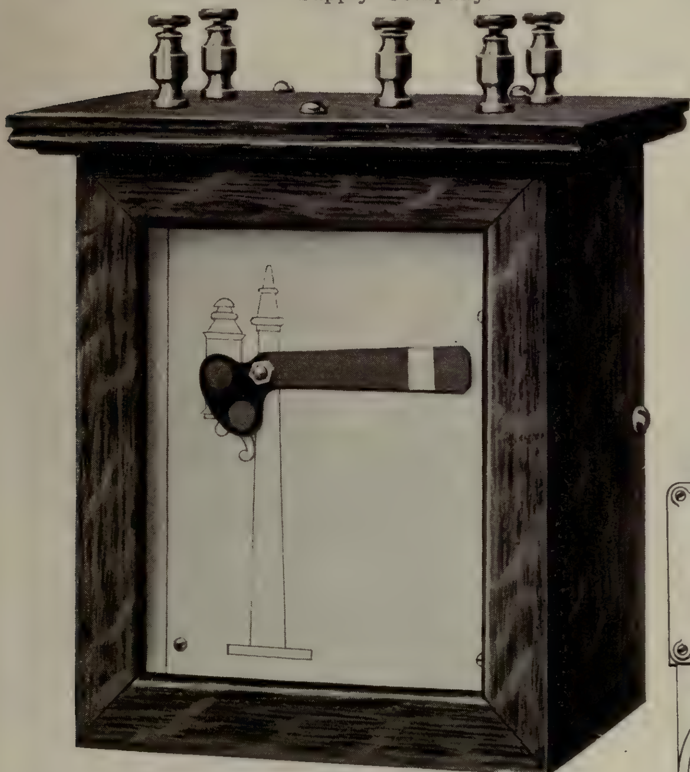
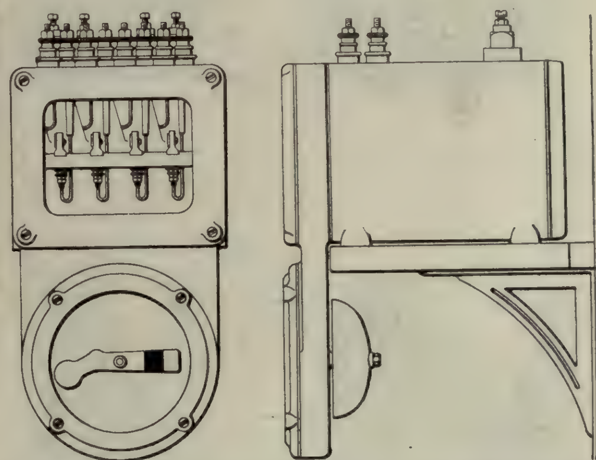


Fig. 2590. Semaphore Indicator. Bryant Zinc Company.



Figs. 2591-2592. Alternating Current Semaphore Indicator.

BRYANT ZINC SEMAPHORE INDICATORS.

The indicators (Fig. 2590) made by the Bryant Zinc Co. are furnished in oak cases, size 6 in. x 7 in., and are designed for use in interlocking towers and signal stations. They can be supplied with two contacts, either front or back. When wound to 50 ohms resistance, they will operate on .03 ampere. Either a 60 or 90 deg. indication can be used.

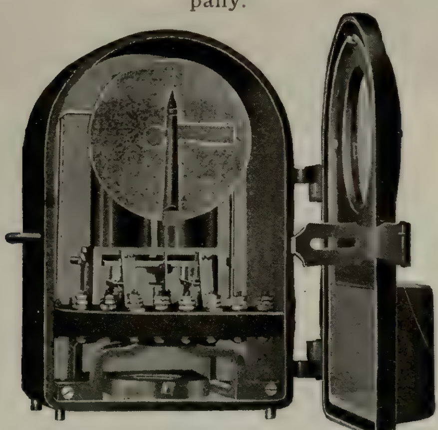


Fig. 2593. Style "A" Semaphore Indicator. Railroad Supply Company.

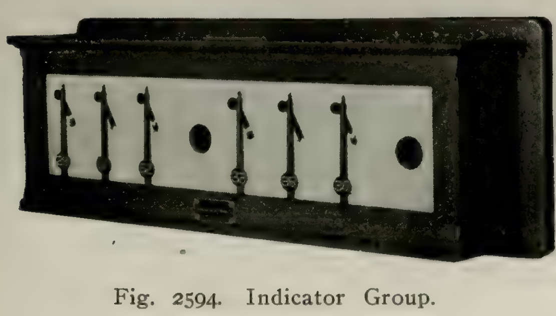
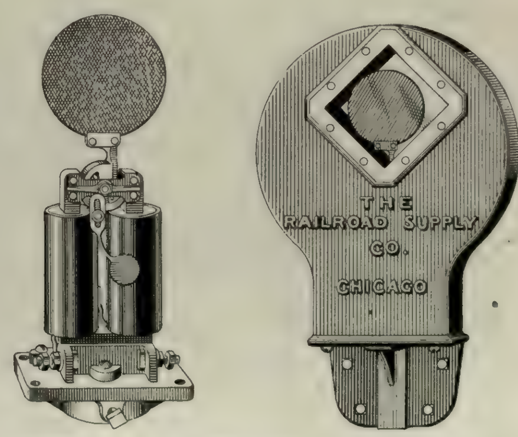


Fig. 2594. Indicator Group.



Figs. 2595-2596. Disk Indicator. Railroad Supply Company.

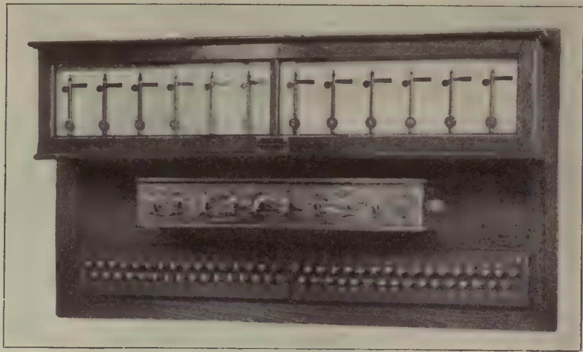


Fig. 2597. D. C. Indicator Group (Style "A"), with Hand Screw Releases and Terminal Board. General Railway Signal Company.

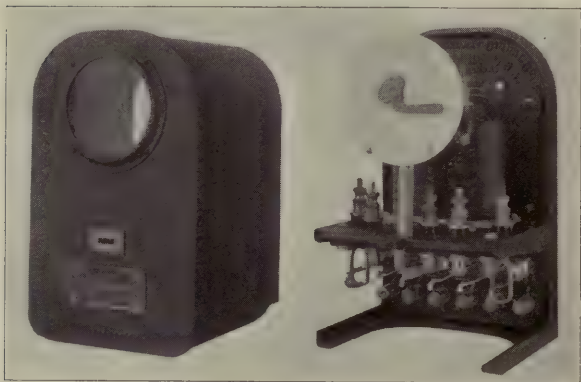


Fig. 2598. Universal D. C. Indicator Model 9, Form "A" (4-way). General Railway Signal Company.

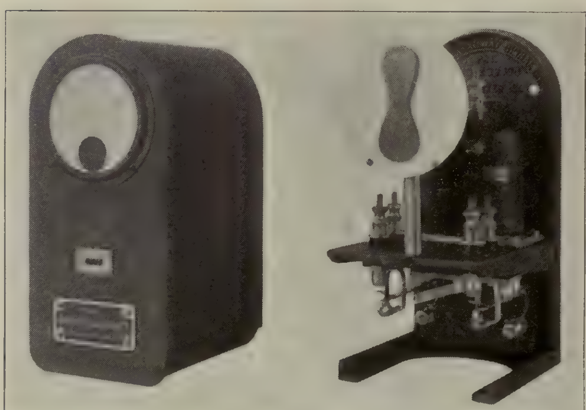


Fig. 2599. Universal D. C. Disc Indicator Model 9, Form "A" (2-way). General Railway Signal Company.

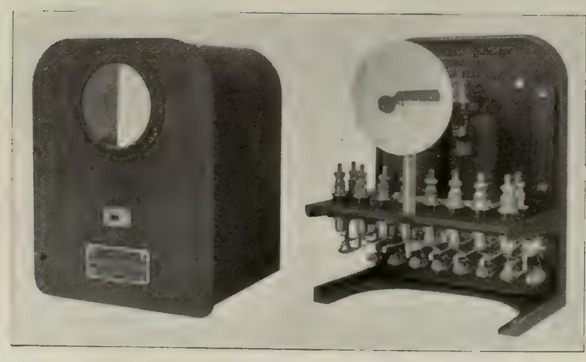


Fig. 2600. Universal D. C. Indicator Model 9, Form "A" (6-way). General Railway Signal Company.

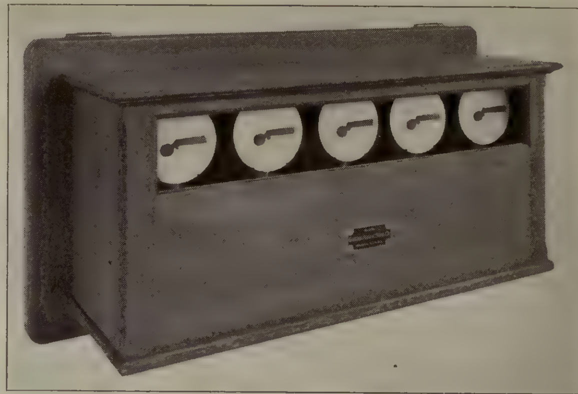


Fig. 2601. Universal D. C. Indicator Group. Model 9, Form "A." General Railway Signal Company.

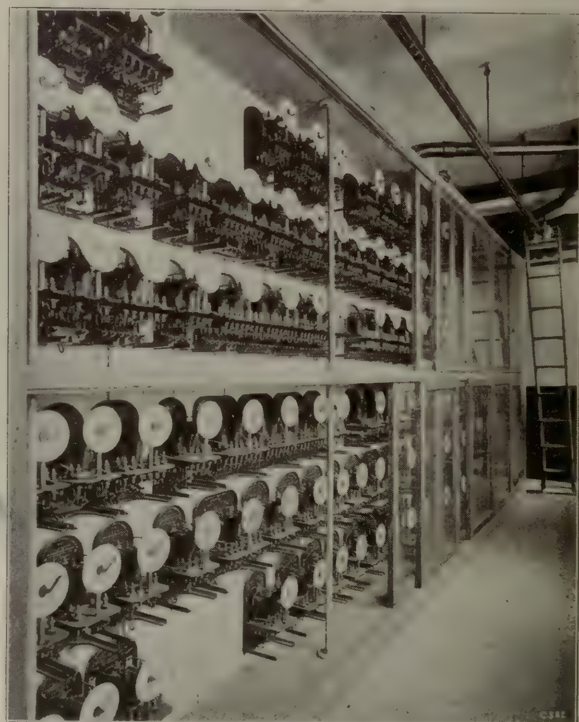


Fig. 2602. Installation of Model 9, Form "A." Indicators. Chicago & North-Western.

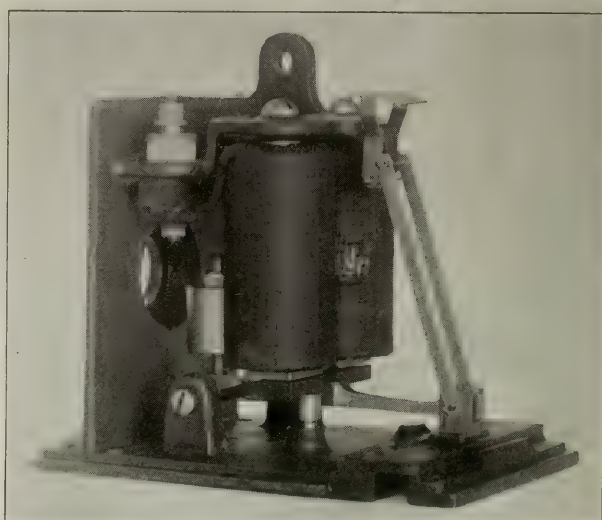


Fig. 2603. Universal Electric Lock for Mechanical Interlockers, Model 5, Form "A." General Railway Signal Company.

G. R. S. DIRECT CURRENT INDICATORS.

Fig. 2598 shows the Model 9 Form "A" tower indicator, which to all intents and purposes is a Model 9 relay, arranged with an indicating device. It is provided with a light sheet-iron cover, which is easily removable, but which may be locked if desired. The indicator is a "unit" construction which can be grouped on shelves, or screwed to the wall in the manner shown in the C. & N. W. Ry. installation, Fig. 2602.

The device is also put out in the form of a switch indicator, as shown in Fig. 2636. The case is weatherproof, the back door being removable and secured by the G. R. S. standard cam hasp.

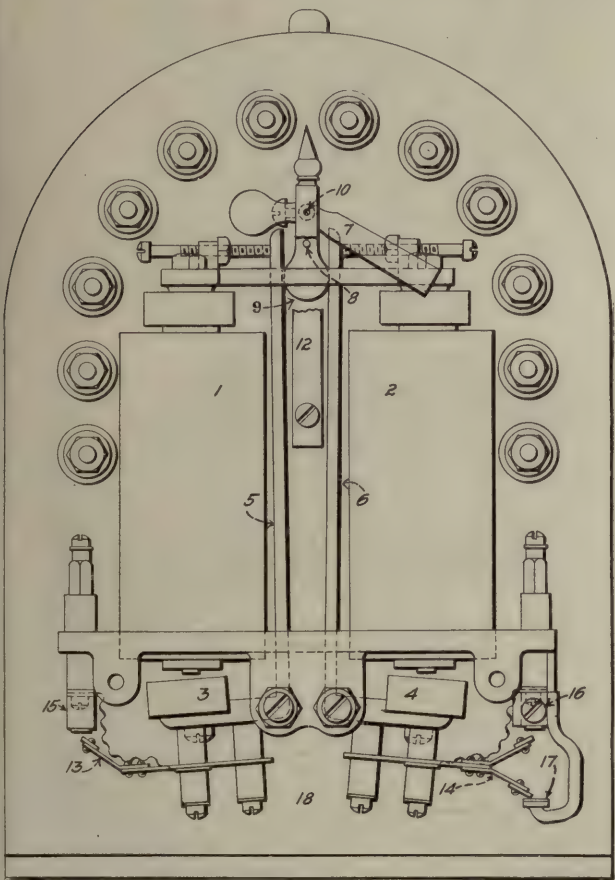


Fig. 2604. Three-Position Signal Repeater. Federal Signal Company.

THREE-POSITION SIGNAL REPEATER.

The three-position signal repeater, shown in Fig. 2604, consists of two magnets, 1-2, and their armatures, 3-4. These armatures are connected with levers 5 and 6, which move the miniature semaphore 7 to the clear or stop position by striking pin 8 on counterweight 9, secured to shaft 10, on which is mounted the semaphore arm 7. Connected to armature 3-4 are contact fingers 13-14. Front contacts 15 and 16, and, if required, back contacts 17 are provided. Binding posts are mounted on the back of the frame 18. A cover with glass front is placed over the mechanism. The operation of the repeater is as follows: A circuit controller on the signal closes the circuit through magnet when the signal assumes the stop position. This throws miniature semaphore arm to the corresponding stop position by lever 5 striking pin 8. When the signal assumes the proceed position, circuit through magnet 1 is broken, circuit through magnet 2 is closed and the arm is moved to the clear position by lever 6. The controller on the signal is so arranged that when the signal arm is 15 degrees below stop, or 15 degrees above proceed position, neither magnet 1 nor 2 is energized and the arm will assume a middle position, as shown in the figure, owing to the counterweight 9 swinging into a vertical position. The back and front contacts can be used for making or breaking circuits.

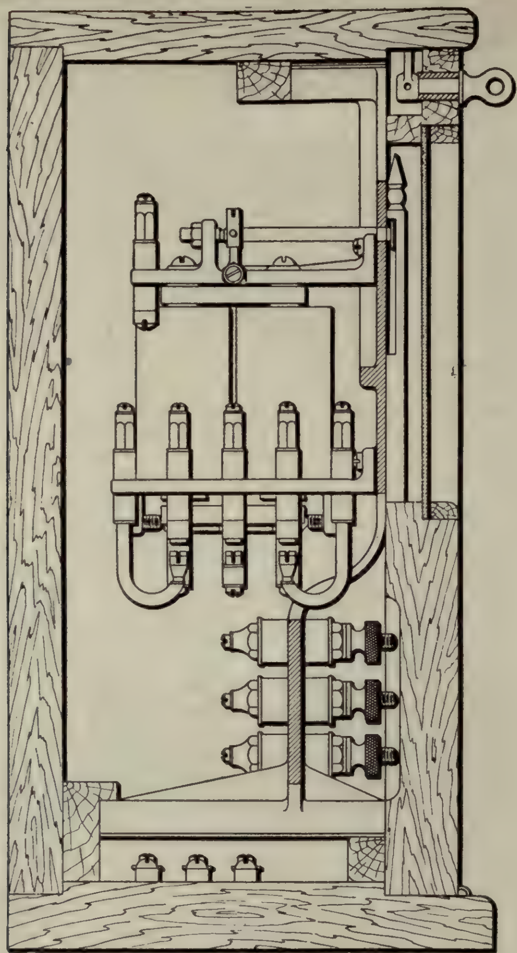
THE TRAIN DESCRIBER.

The train describer made by the Union Switch & Signal Company, shown in Figs. 2605-2606, provides 16 indications which may describe express or local passenger, freight, light engines and other classes of trains; and give directions as to what route they are to take. Also indications may be provided to convey other information such as "cancel," "repeat," etc. They are generally operated in sets consisting of one transmitter and one receiver, though one transmitter may operate two or more receivers, or one receiver may show indications from two or more transmitters. The transmitter is a make and break circuit controller driven by a key-wound spring, which is released to send a certain number of current impulses over a line to the receiver when the corresponding numbered disk is pushed. The receiver consists of a magnet operating an armature, ratchet and the pointer on the face of the instrument, the ratchet limiting the action of each impulse to a certain movement designed to rotate the pointer from one number to the next. Means are provided for manually operating the receiver, if necessary, to correspond with the transmitter by pushing the button on the lower left-hand side. Bells are usually employed in addition to the instruments shown. Fig. 2617 shows train describers in place on a director board.

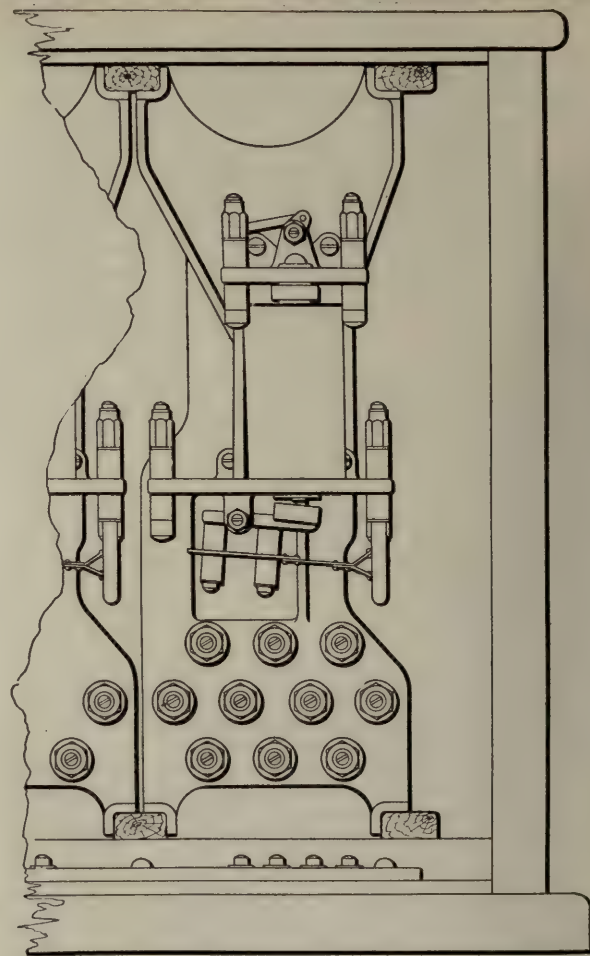
Transmitter.

Receiver.

Figs. 2605-2606. Train Describing Instrument. The Union Switch & Signal Company.



Side View Arrangement of Coils and Contacts.



Rear View of Single Unit.

Figs. 2607-2608. Multiple Unit Indicator with Wooden Case. The Union Switch & Signal Company.

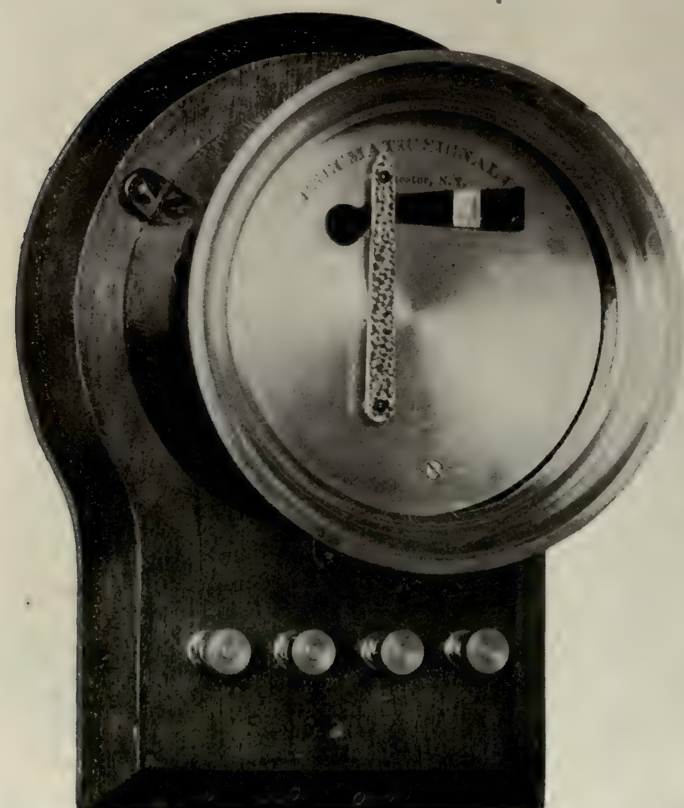


Fig. 2609. Semaphore Indicator. General Railway Signal Company.

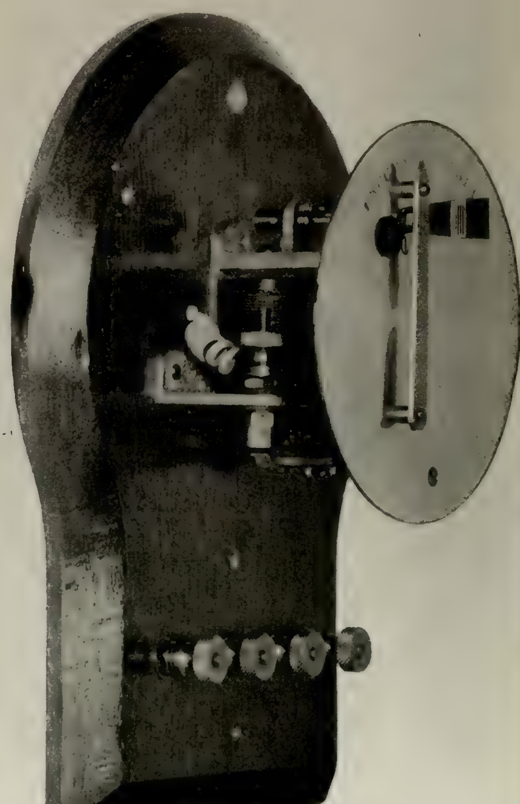
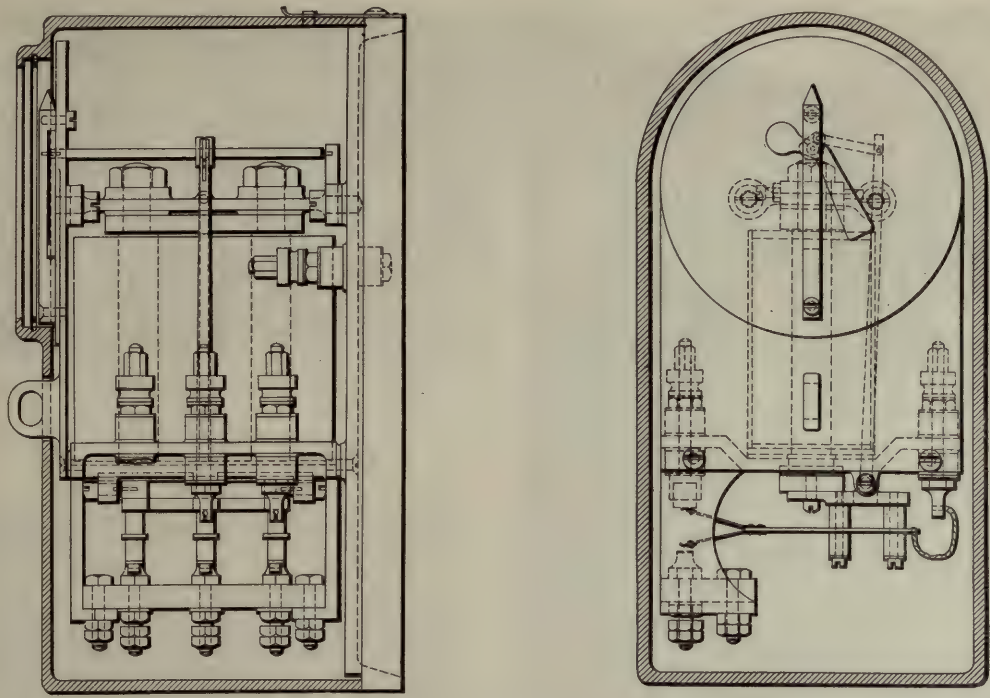


Fig. 2610. Semaphore Indicator. (Fig. 2609) with Case Removed.



Figs. 2611-2612. Semaphore Indicator. American Railway Signal Company.

Fig. 2613. Iron Case Indicator, with Enclosed Pointer, Polarized Type. The Union Switch & Signal Company.

Fig. 2614. Iron Case Semaphore Indicator, Neutral Type. The Union Switch & Signal Company.

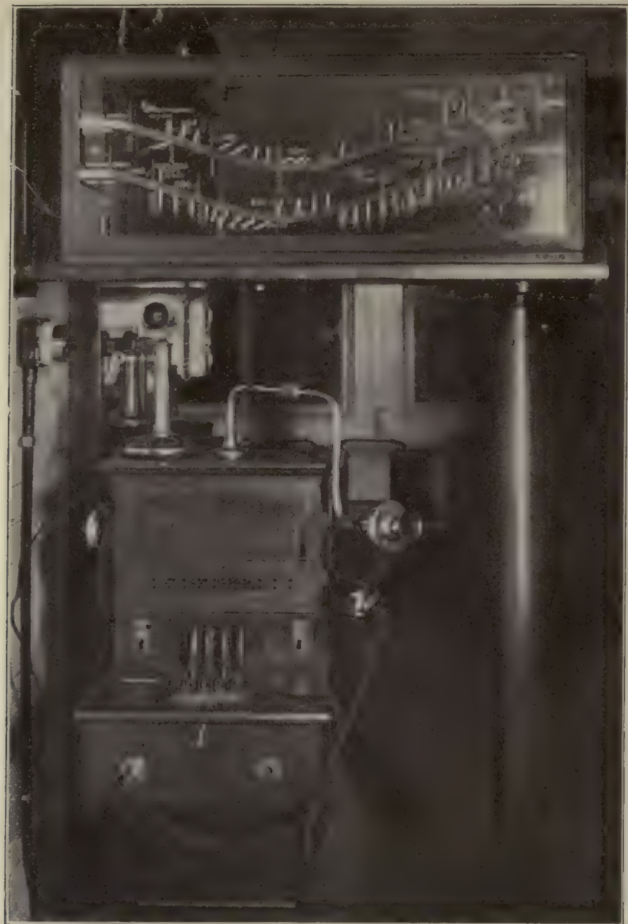


Fig. 2615. Illuminated Track Indicator and Operator's Desk. Interborough Rapid Transit Company.

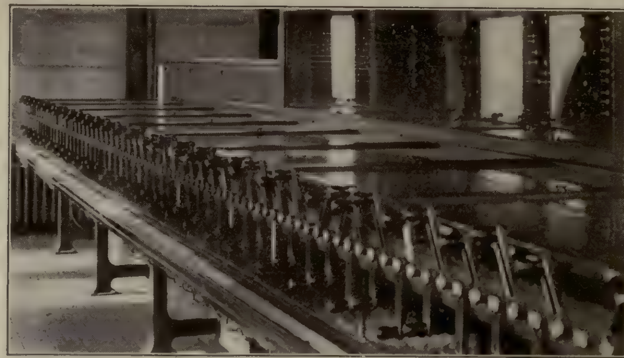


Fig. 2616. Electro-Pneumatic Interlocking Machine, with Illuminated Indicators Beneath Levers. Delaware, Lackawanna & Western. The Union Switch & Signal Company.

In Fig. 2616 the Illuminated Indicators on the front of the machine are on the "Ledge," indicated in the illustration.

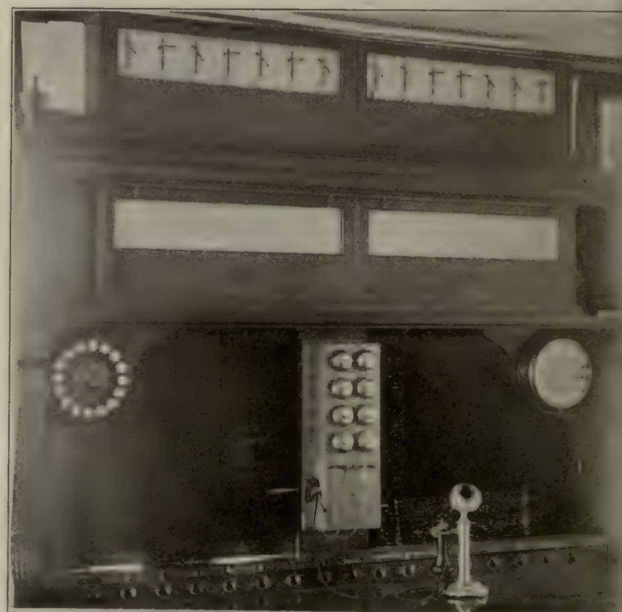
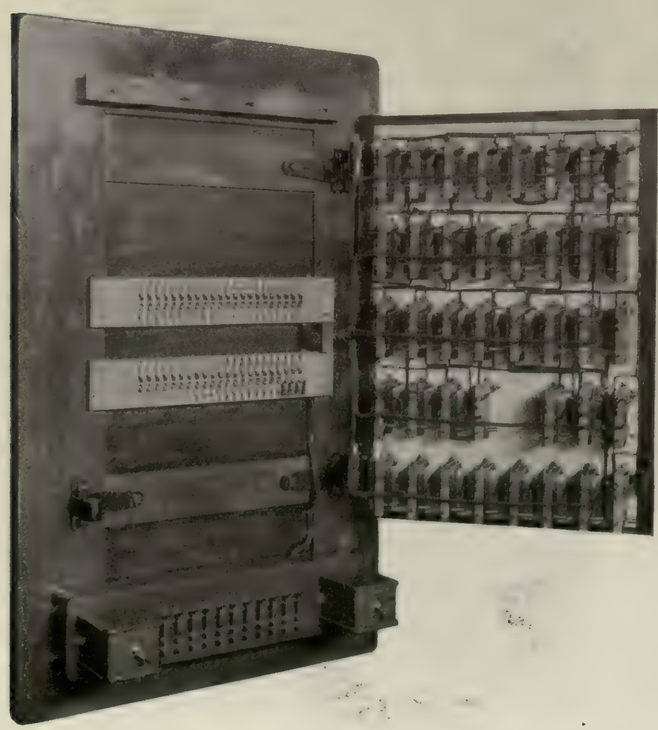


Fig. 2617. Train Director's Board and Instruments, Delaware, Lackawanna & Western. The Union Switch & Signal Company.



Figs. 2618. Train Director's Board (Fig. 2619) with Case Open. Showing Details of Wiring and Connections.

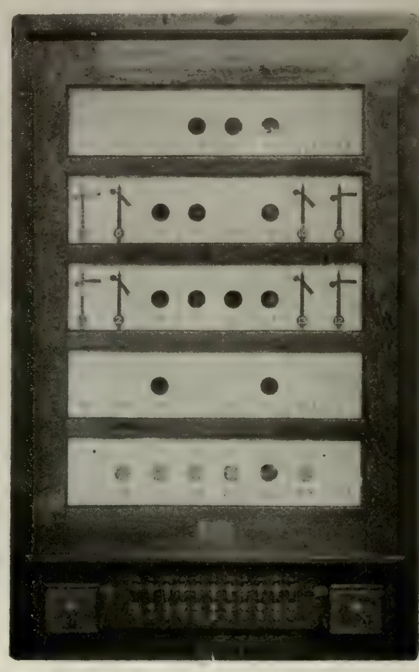


Fig. 2619. Train Director's Board. General Railway Signal Company.

Names of Parts of Lamp Indicator Apparatus; Fig. 2621.

A	*Thermostatc Circuit Controllers*	K	*Banner*
B	*Expanding Spiral*	L	*Adjustable Stop*
C	*Contact Post*	M	*Coil Terminal*
D	*Bell*	N	*Ground Terminal*
E	*Bell Battery*	P	*Bell Circuit Terminal*
F	*Relay*	Q	*Line Terminal*
G	*Spool Lightning Arrester*	R	*Coil Terminal*
H	*Pointer*	S	*Line Battery*

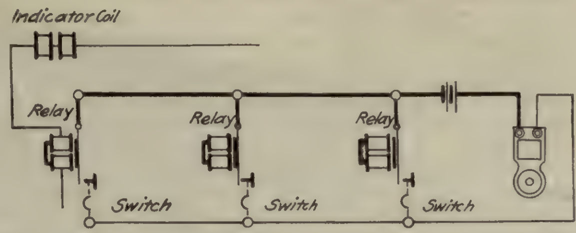


Fig. 2620. Arrangement of Circuits for Operating One Bell from Several Lamp Indicators.

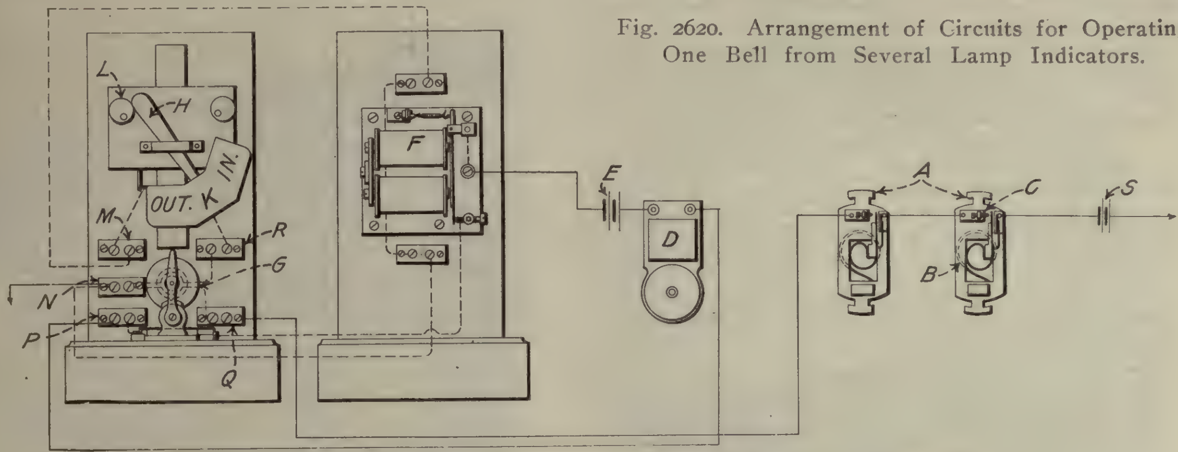
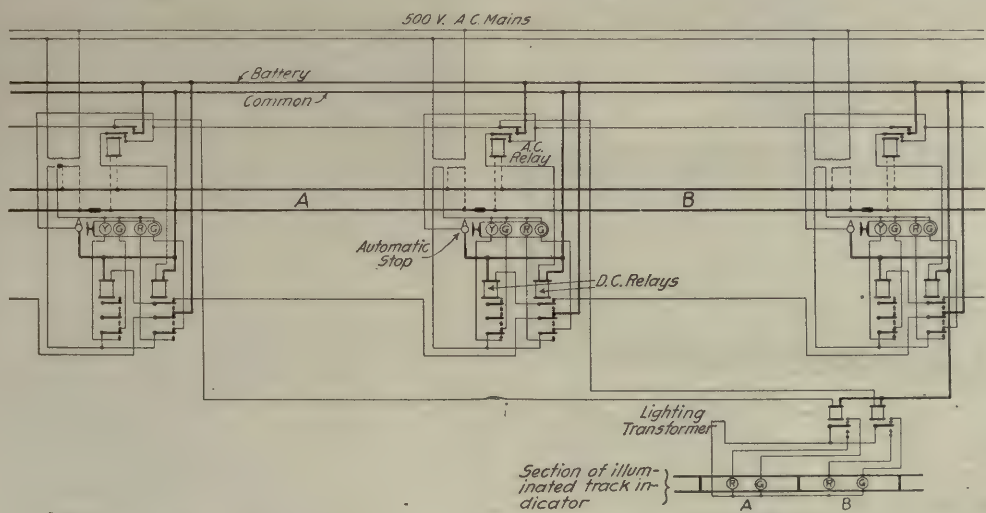


Fig. 2621. One Indicator Connected to Operate with Two Lamps.

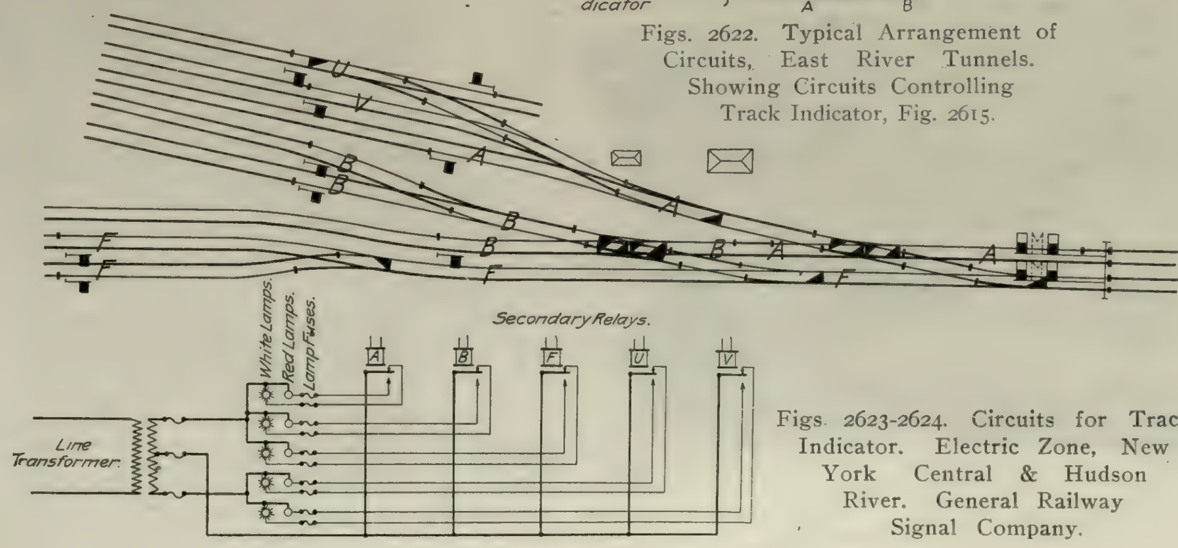
Figs. 2620-2621. Circuits for Lamp Indicators. Great Western Railway of England.

LAMP INDICATOR.

Figs. 2620-2621 show the circuits and apparatus used by the Great Western Railway of England, to indicate to a signalman whether or not the signal lamps are lighted. In the illustration two thermostats A are shown, one for each of two lamps. The thermostat consists of a spiral of readily expanding metal B,



Figs. 2622. Typical Arrangement of Circuits, East River Tunnels. Showing Circuits Controlling Track Indicator, Fig. 2615.



Figs. 2623-2624. Circuits for Track Indicator. Electric Zone, New York Central & Hudson River. General Railway Signal Company.

connected electrically to the battery S. The other side of the battery is connected to ground. When the lamp is lighted the spiral B expands and makes contact at C, completing the circuit from battery S, through the thermostat controller, coil of the indicator, coils of the relay to ground (terminal N), back to battery. This energizes the indicator and the pointer H moves the banner K so as to show "In" at an opening in the cover (not shown). If one of the lamps is extinguished its thermostat opens the circuit and de-energizes the indicator, causing the banner to display "Out." The indicator is constructed like block indicator shown in Fig. 341, and operates in the same manner. F is a relay controlling the bell D. The adjustable stop L on the indicator limit the travel of H.

A local circuit is operated by the back contact on the relay F to ring the bell in case any lamp should go out. In the daytime, when the lamps are not needed, the bell circuit is cut out by the switch shown just beneath the lightning arrester.

FEDERAL TRACK INDICATOR.

In the track indicator made by the Federal Signal Co., the different track circuit sections are represented by a length of tube supported at the ends so as to be free to revolve. These tubes are so placed that a portion is displayed through slots cut in the front plate, upon which the track and connections and signals are drawn. If the track is occupied or not clear, the portion of the tube showing through the slot in the front plate will be red, whereas if the track is unoccupied and clear the part of the tube showing will be white. The tubes are operated by electro-magnets controlled through the track circuits; and these electro-magnets can be arranged for direct or alternating currents.

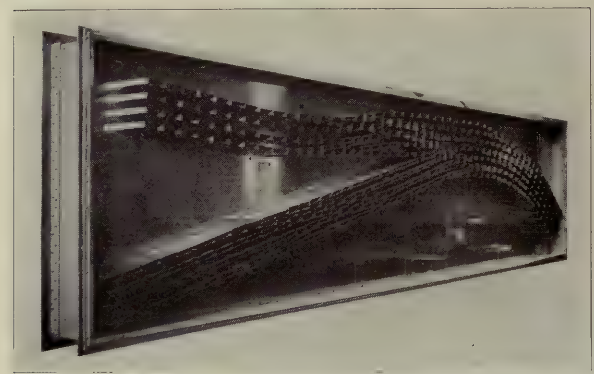


Fig. 2625. Front View (Glass Removed) of Illuminated Track Diagram. Chicago & North-Western. General Railway Signal Company.

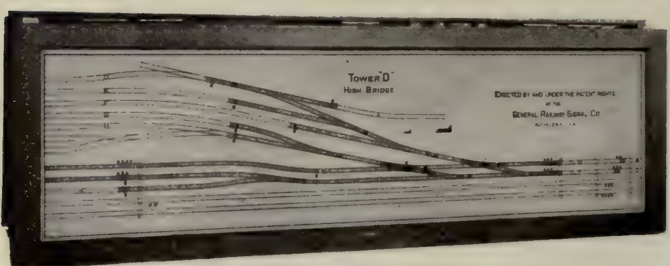


Fig. 2627. Illuminated Track Diagram. Electric Zone. N. Y. C. & H. R. R. R. General Railway Signal Company.

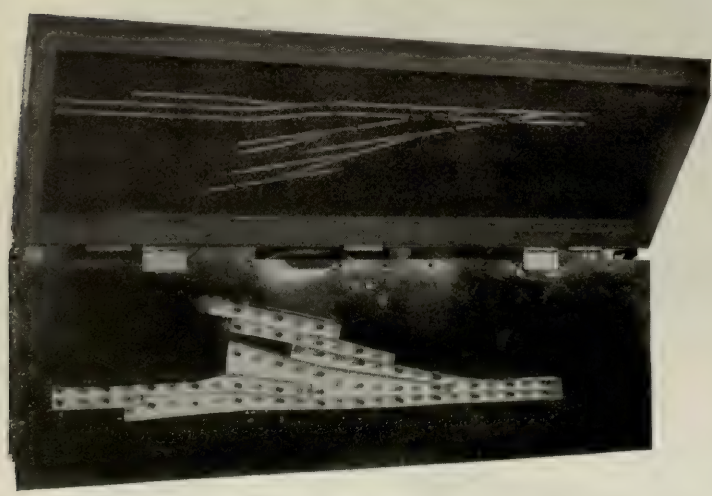


Fig. 2628. Track Indicator Shown in Fig. 2627, with Glass Front Raised Showing Arrangement of Lamps and Channels.

G. R. S. TRACK INDICATOR.

Figs. 2627-2629 illustrate a track indicator illuminated by electric lights and typical circuits for operating same. The indicator consists of a box, the cover of which contains a glass plate painted to show a diagram of the tracks, switches and signals concerned. The part representing the sections covered by the track indicator is transparent, the rest being opaque. Within the box are rows of electric lights corresponding to the transparent track sections on the glass. Each row of lights is enclosed in a small channel so that the light can shine only at right angles to the back of the box, and each row is divided to correspond with the track circuit sections. The lights are alternately red and white. When a track section is unoccupied the white lights burn; the presence of a train extinguishes them and causes the red lights to burn, so that the signalman is kept constantly informed of the conditions of the track sections at his plant. The apparatus illustrated was made by the General Railway Signal Company and installed on the Electric Zone of the New York Central & Hudson River, and at the Chicago Terminal of the Chicago & North Western Railroad.

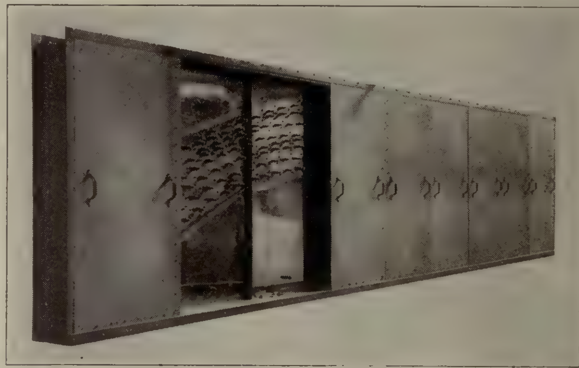


Fig. 2626. Rear View of Illuminated Track Diagram. Chicago Terminal. Chicago & North-Western. General Railway Signal Company.

U. S. & S. TRACK INDICATOR.

Figs. 2615 and 2622 illustrate a track indicator designed by the Union Switch & Signal Company and installed in connection with the automatic block signals in the East River tunned of the Interborough Rapid Transit Company. As will be seen from a comparison of the circuit diagrams, it is operated in the same manner as the indicator illustrated in Figs. 2627-2628, the principal difference being that green lamps are used instead of white to indicate that the track is unoccupied.

Fig. 2616 shows an illuminated indicator attached to the levers of an electro-pneumatic interlocking machine, which shows when the track section in which the function occurs is occupied by a train. This is accomplished by an electric light behind a ground glass beneath each lever. When the track section is unoccupied the light burns.

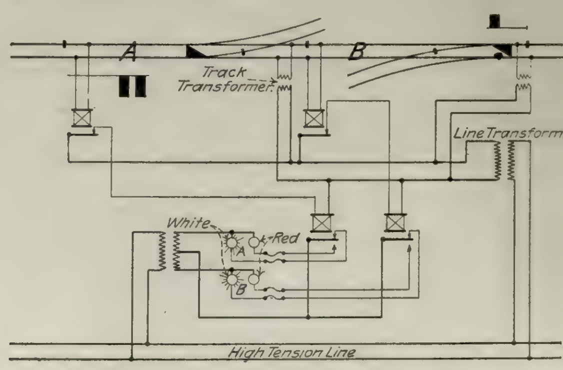


Fig. 2629. Typical Circuits for Track Indicator Operated by Alternating Current. General Railway Signal Company.

SWITCH INDICATORS.

Where switches occur in block signalled territory they are frequently protected by switch indicators. These may give a visual or audible indication or both. Visual indications are given by an electrically operated semaphore arm or disk mounted in an iron case on a post. Audible indications are given by bells. Indicators are placed near the switch and are controlled by circuits in such a manner as to announce the approach of a train by the horizontal position of the arm, presence of the disk or ringing of the bell when the train is a certain distance away, usually when it is approaching the distant signal for the block in which the switch occurs. When such announcement is given the switch must not be opened until the train has passed.

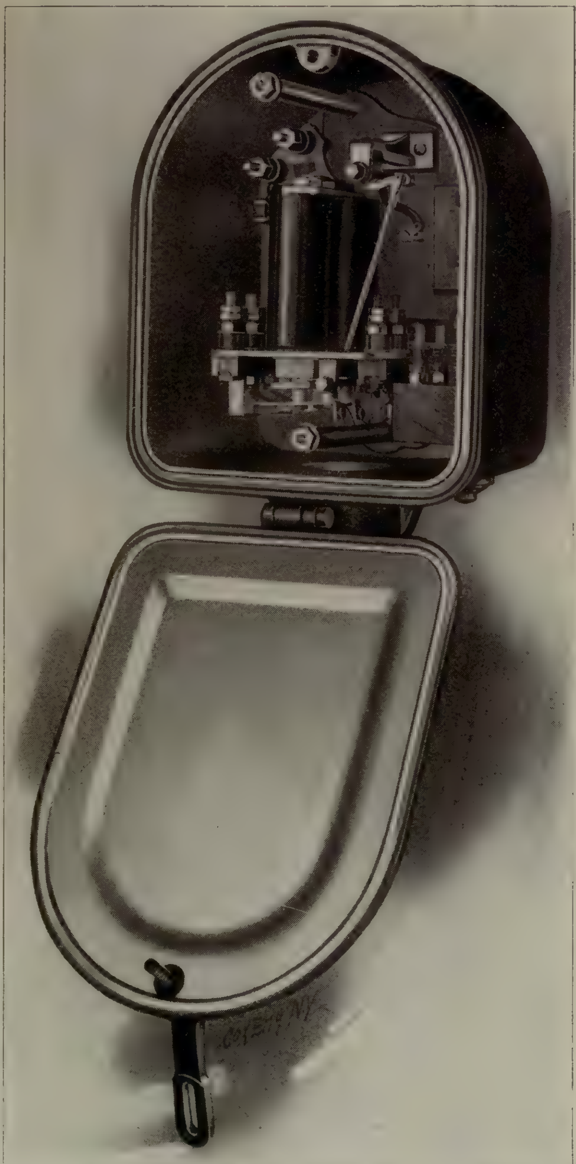


Fig. 2630. Switch Indicator with Push Button. Hall Signal Company.

AMERICAN SIGNAL COMPANY'S SWITCH INDICATOR.

The American Railway Signal Company makes the semaphore switch indicator shown in Figs. 2643-2644. The mechanism is contained in a cast iron case designed to be screwed on top of a pipe post. The magnet is mounted vertically, the armature below, and operates the semaphore arm by an up and down rod and a lever.

Figs. 2650-2651 show a semaphore switch indicator with rotary armature and differential coils. The armature is of the Z type and actuates the arm direct. There are two windings on the magnet, one of a low resistance, which operates the indicator, and one of high resistance, which, in series with the first, holds the indicator in the clear position. The high resistance is controlled by a circuit breaker on the shaft.

The alternating current switch indicator (Figs. 2658-2659) is provided with an electric light mounted on the door, which illuminates the face at night.

G. R. S. UNIVERSAL POLYPHASE INDICATOR.

The indicator shown in Figs. 2646-2647 is of the same construction as the General Railway Signal Company's Model 2

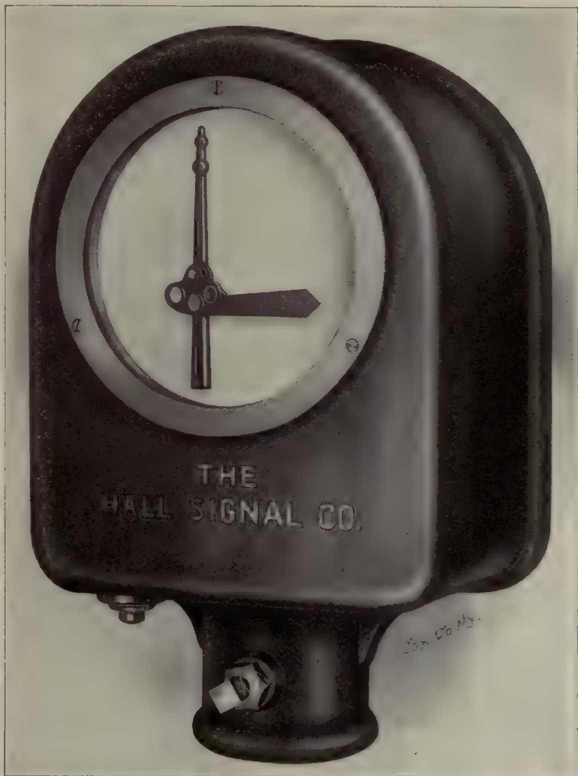


Fig. 2631. Switch Indicator with Push Button. Hall Signal Company.

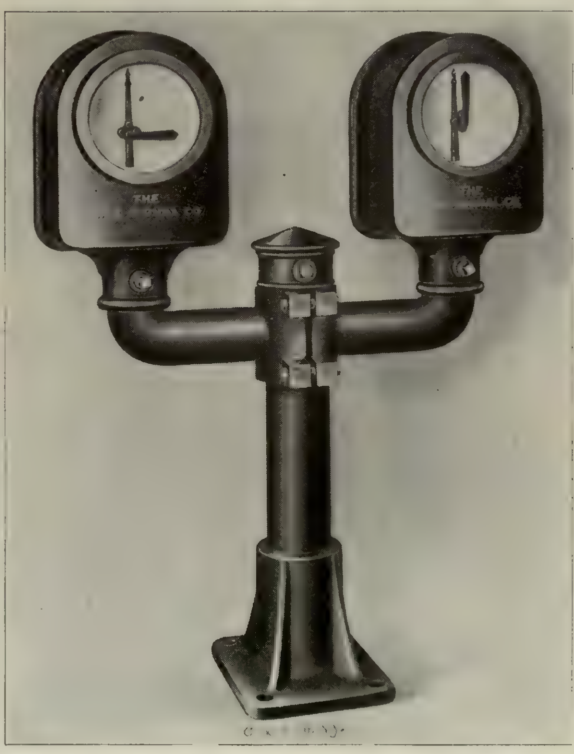


Fig. 2632. Double Switch Indicator and Post. Hall Signal Company.

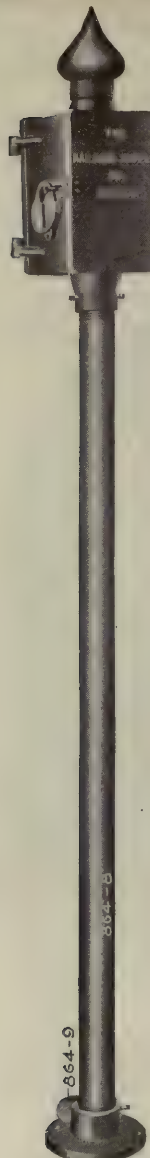
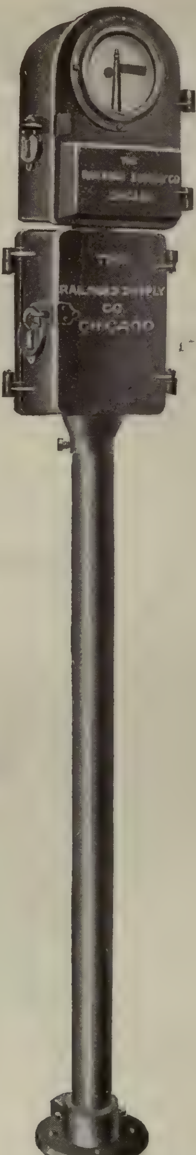
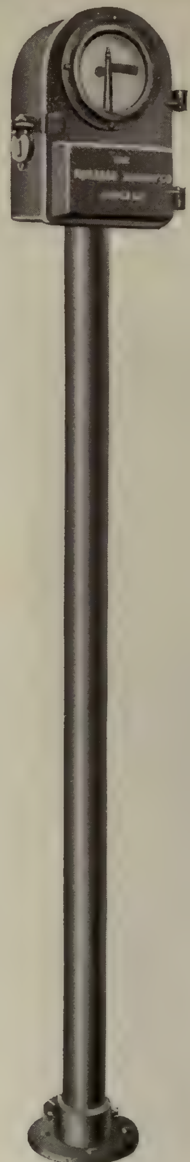


Fig. 2633. Siding Bell Box.





Figs. 2634-2635. Style "A" Switch Indicators. Railroad Supply Company.

[Fig. 2634 shows the Indicator equipped with vibratory bell and push-button box.]

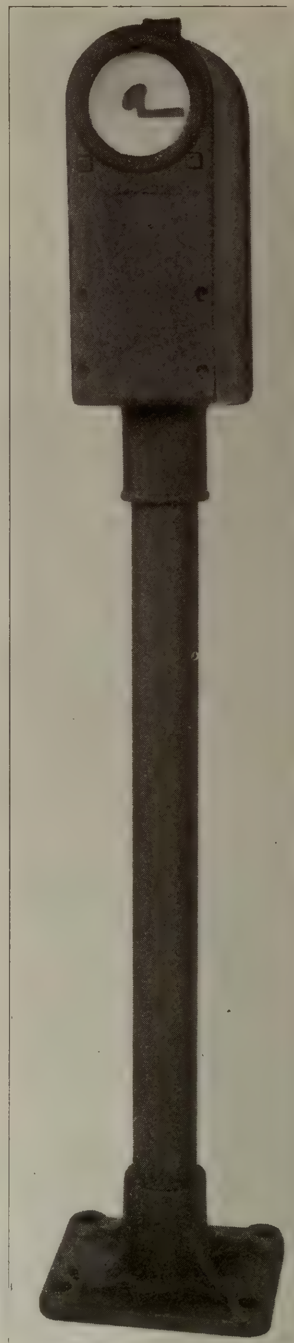
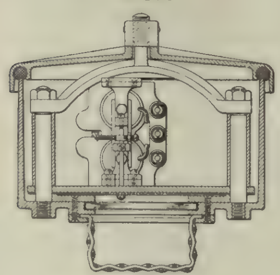
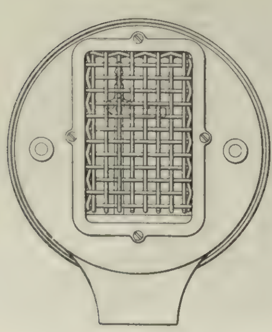
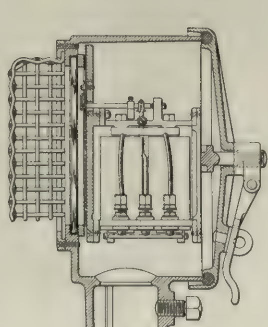


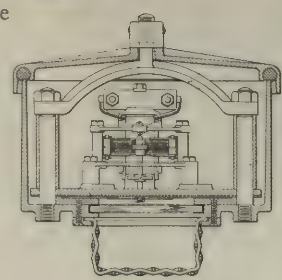
Fig. 2636. Universal D. C. Switch Indicator. Model 9, Form "A." General Railway Signal Company.

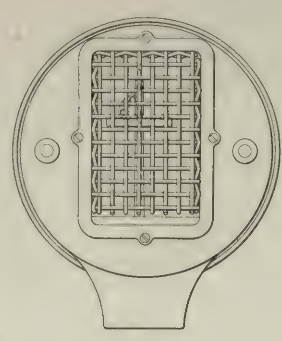


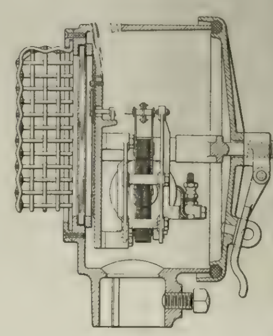




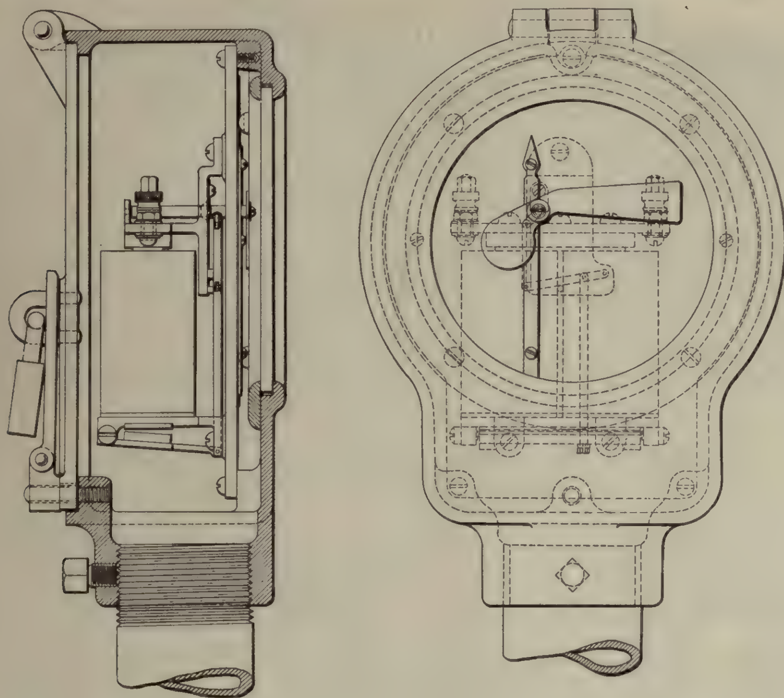
Figs. 2637-2639. D. C. Iron Case Switch Indicator. The Union Switch & Signal Company.







Figs. 2640-2642. A. C. Iron Case Switch Indicators. The Union Switch & Signal Company.



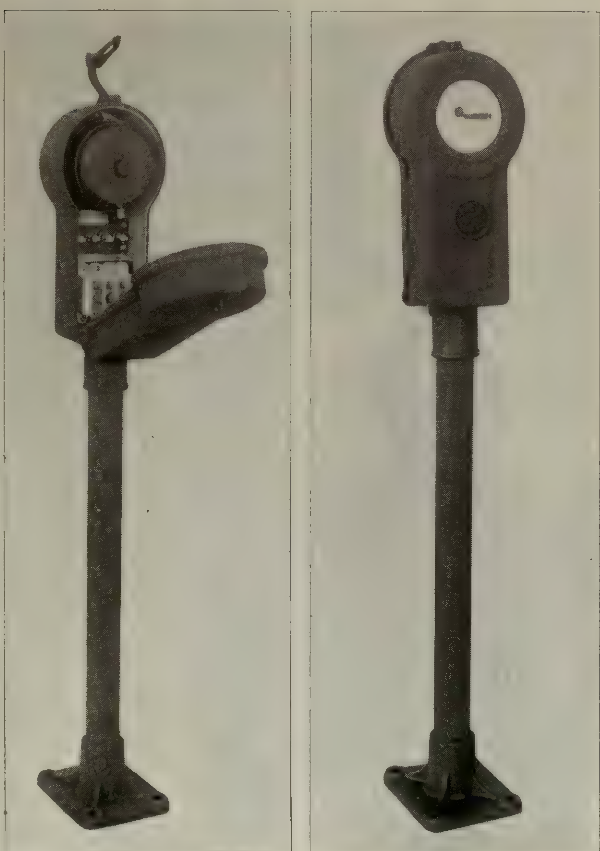
Figs. 2643-2644. Semaphore Switch Indicator. American Railway Signal Company.

Fig. 2645. Switch Indicator on Iron Post. Hall Signal Company.

Form A polyphase relay. The case is designed to accommodate a terminal board and lightning arrester.

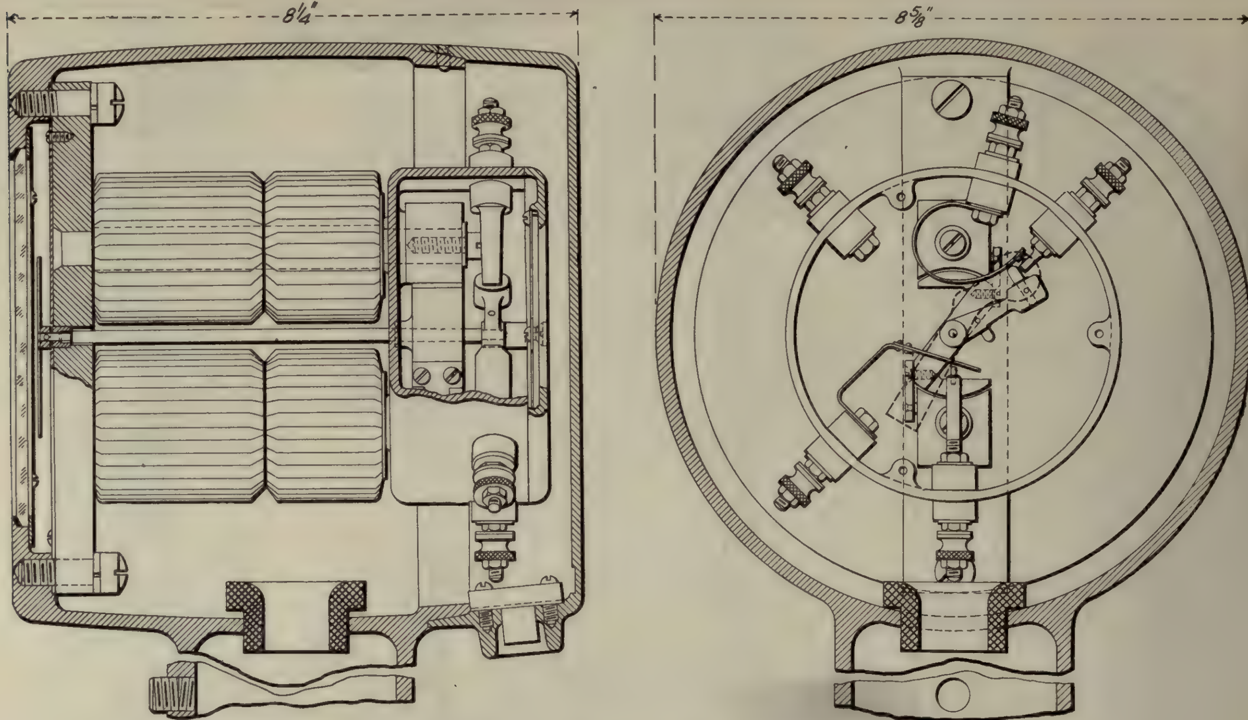
The G. R. S. Co.'s polyphase relays and indicators are operated by means of a two-phase induction motor (track and local phase). Each of these two windings must be supplied with current having the proper phase relation, polarity and frequency to ensure operation of the relay. It is rendered immune to foreign or track current by the use of the G. R. S. non-magnetic rotor. The design is such that the breaking down of insulated joints will cause the relay contacts to open.

Fig. 2636 shows the Universal D. C. switch indicator, Model 9 Form A, made by the General Railway Signal Company.



Figs. 2646-2647. Universal Polyphase Switch Indicator, Model 2, Form "A." General Railway Signal Company.

Figs. 2648-2649. Semaphore Switch Indicator with Rotary Armature and Differential Coils.

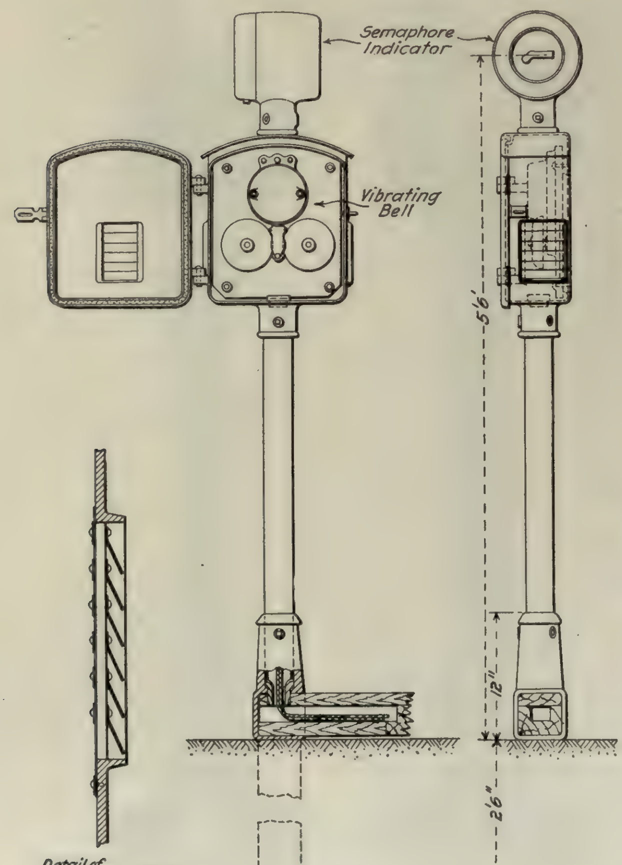


Figs. 2650-2651. Details of Semaphore Indicator.

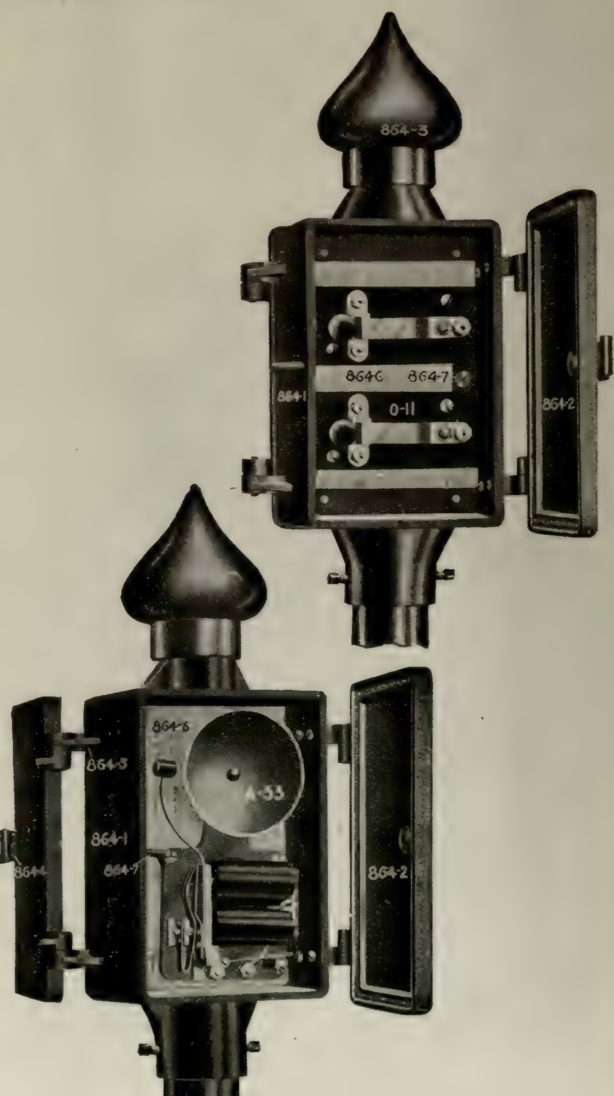
HALL SWITCH INDICATORS.

Figs. 2630-2631 show the mechanism of the switch indicator made by the Hall Signal Company, and a front view of the indicator. This instrument is equipped with a push button which is mounted on the lower side of the indicator case as shown in the figures.

A disk switch indicator, which gives night indications, is illus-



Figs. 2652-2653. Semaphore Switch Indicator with Bell Added.



Figs. 2654-2655. Siding Bell Box. Railroad Supply Company.

trated in Figs. 2652-2653. A disk which carries a colored celluloid center is moved in front of the white lens of a lamp by being connected to the Z armature of an electromagnet. The presence of current in the magnet raises the disk to show a clear signal, while the absence of current causes a counterweight to restore the disk to the stop or caution position. This illuminated type is used most frequently in yards where the indicators must be placed at some distance from the switch because of insufficient clearance between tracks for the usual type. These instruments may be used at exits to passing sidings instead of dwarf signals. Wires are brought up through the base and the pipe post. The mechanism is enclosed in an iron case which has a removable back.

Figs. 2663-2665 illustrate a semaphore switch indicator made by the Union Switch & Signal Company. It consists of a magnet mounted in an iron case which operates a semaphore arm through its armature and a crank and link. The armature is below the magnet and the semaphore arm is carried on a shaft above the magnet. The shaft projects through a white face plate used as a background for the arm. In the figure is shown a cast iron pipe post and foundation combined.

The semaphore switch indicator with bell (Figs. 2669-2671), made by the Union Switch & Signal Company, is in all respects like the indicator shown in Figs. 2663-2665, except for the addition, below the indicator head, of a bell box containing the bell. Two types are shown.

The polarized switch indicator made by the Union Switch & Signal Company, shown in Figs. 2672-2674, consists of an electromagnet between the poles of which is suspended a permanent magnet. When the electromagnet is de-energized the permanent magnet assumes a neutral position, being held by springs. When the electromagnet is energized, the permanent magnet is attracted to one side or the other, according to the direction of the current in the coils of the electromagnet. The permanent magnet actuates a pointer which stands vertical normally and swings to one side or the other in synchronism with the permanent magnet. This type of indicator is designed to cover the field whereby indication at a distance may be had of the condition of two or more devices or mechanisms. It is especially suited to railway signaling for indicating to a trainman at an outlying passing siding switch: First, the approach of a train; second, the movement of the signal controlling the track section in which the switch occurs, to a position corresponding to that of the outlying switch. In automatic block signaling it may be desirable that a trainman have positive information relative to main line conditions when about to open a switch leading to the main line, and having opened such switch, that the main line signal has moved to the stop position, and that the opening of the switch was the cause of setting the signal. The ordinary neutral type of indicator does not fulfil these conditions. Should a train enter the main line section at the instant the switch was opened by a trainman, it is possible that the trainman might assume that his act of opening the switch had set the main line signal and his train would move out onto the main line, which might cause delay to an approaching train; or he might assume that a train was at the setting section for the indicator and move out onto the main line expecting the approaching train to be held at the home signal, when in reality the approaching train had passed the signal and was in the block containing the passing siding switch, thereby causing a collision risk. It may be used at slotted signals at interlocking plants to indicate an approaching train, the clearing of the signal, and its return to the stop position; or it may be used to indicate whether or not a signal light, not visible from the tower or other point, is in proper condition at night; or for other similar purposes.

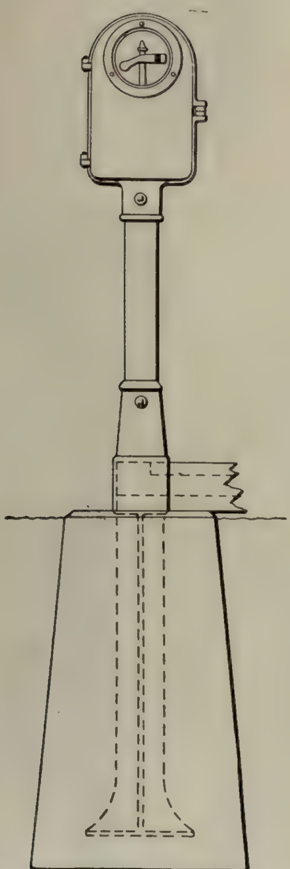


Fig. 2656. Semaphore Switch Indicator Mounted on Iron Pipe Post Set on Cast Iron Base, Embedded in Concrete Foundation.

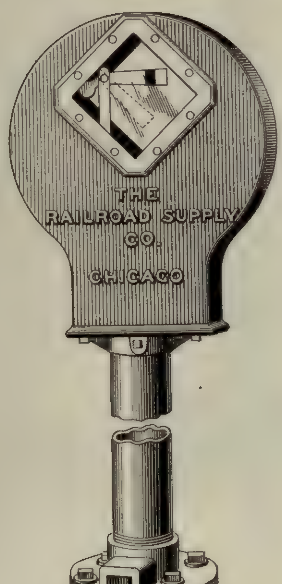
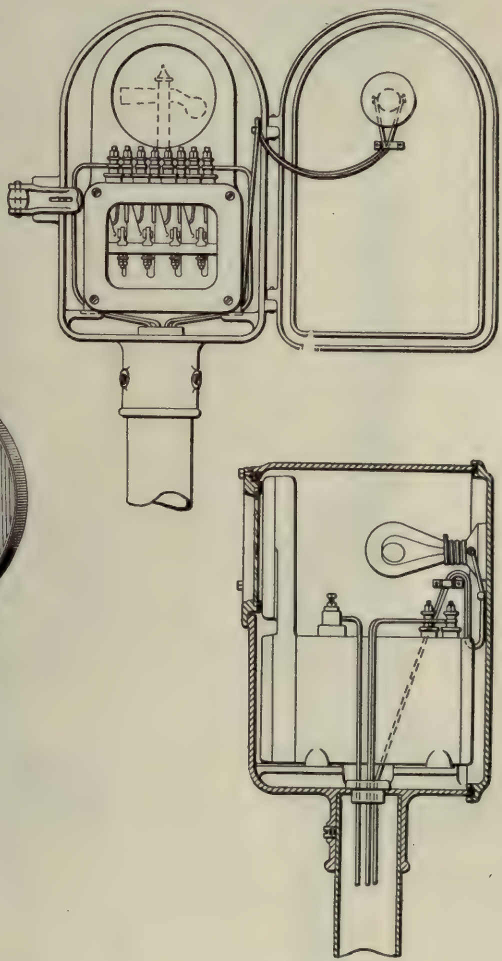
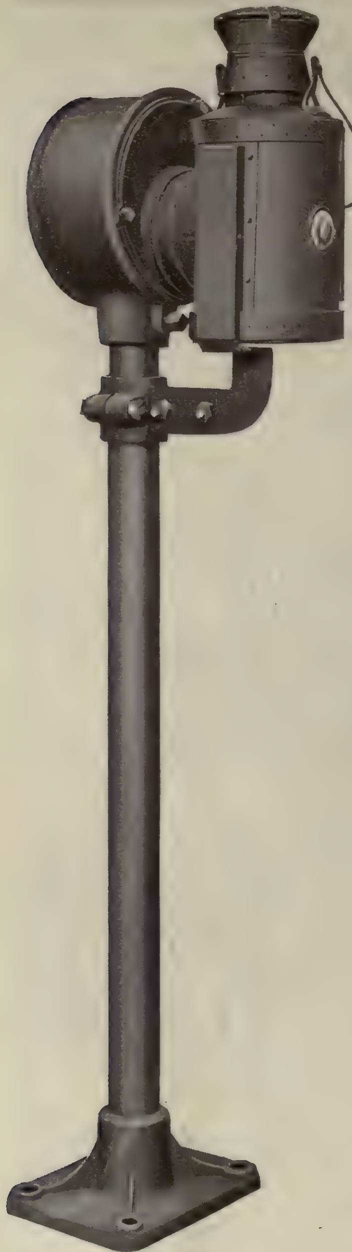
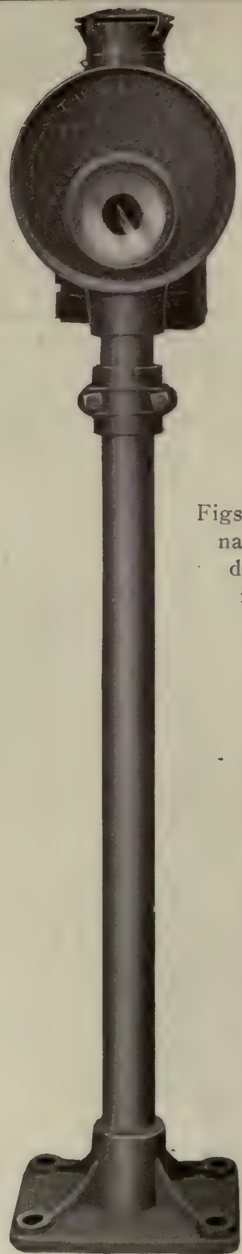


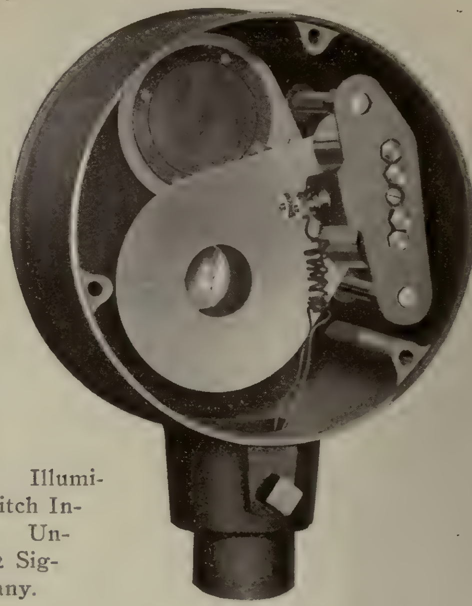
Fig. 2657. Semaphore Switch Indicator. Railroad Supply Company.



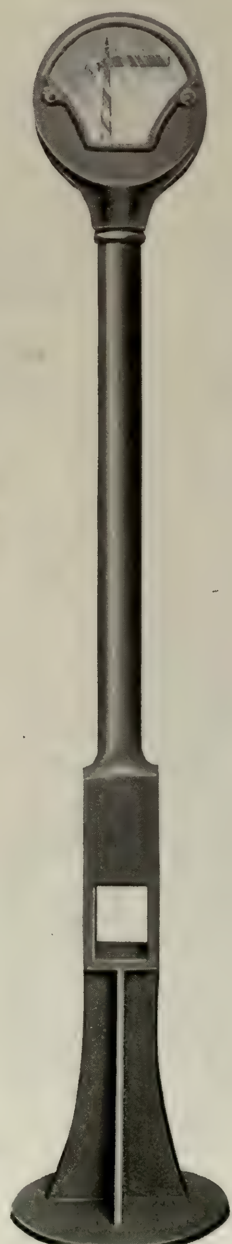
Figs. 2658-2659. Illuminated Alternating Current Semaphore Switch Indicator. General Railway Signal Company.

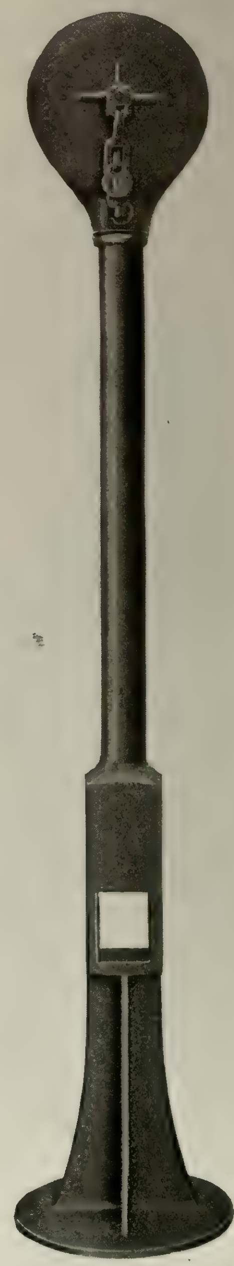


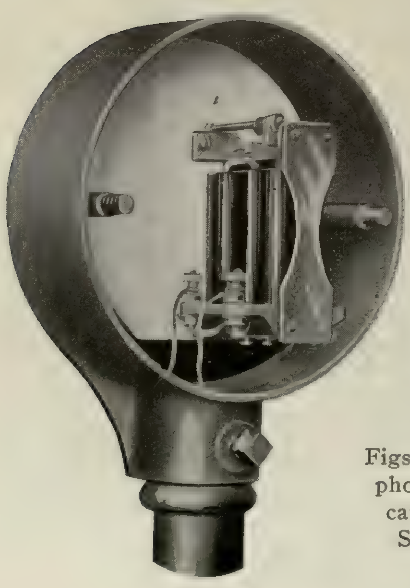




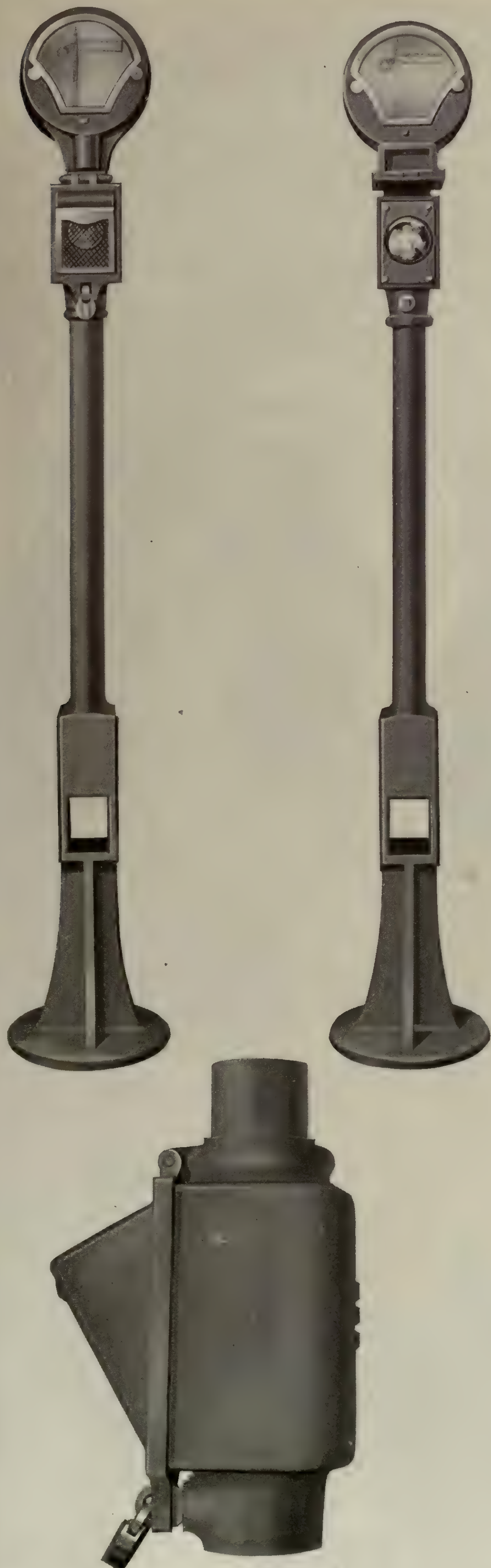
Figs. 2666-2668. Illuminated Disk Switch Indicator. The Union Switch & Signal Company.







Figs. 2663-2665. Semaphore Switch Indicator. The Union Switch & Signal Company.



Figs. 2669-2671. Semaphore Switch Indicator with Bell. The Union Switch & Signal Company.

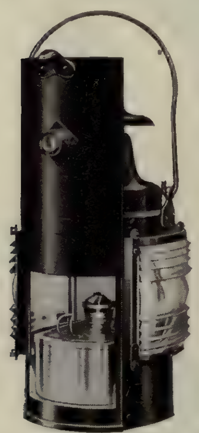
Fig. 2672. Mechanism of Polarized Switch Indicator.

Fig. 2673-2674. Polarized Switch Indicator Mounted on Iron Pipe Post. The Union Switch & Signal Company.

RAILWAY SIGNAL LAMPS

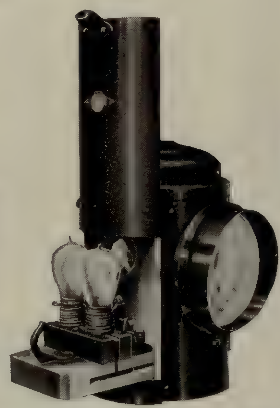
There are now in use a great variety of signal burners ranging from the largest flat wick chimneyless burners, with flame 1 3-8 in. in diameter or more at the optical axis and illumination of three c. p., to the small round flame chimney burners with flame diameter of 3-16 in. and 0.25 and 0.35 c. p. Burners of the larger sizes are commonly known as "one day" burners, being designed for daily attendance. Many railway men favor them to-day for use wherever conditions permit, on account of the increased spread of light from lanterns and the superior stability of flame in windy weather. These burners are open to one serious objection, the large flame and the small size of the present signal lanterns combine to raise the temperature of the oil pot beyond the safety point in hot weather, especially with oil running as low as 125 deg. F. fire test, which is not infrequent. Lanterns so equipped have more than once caught fire, though the danger from this would not be great were 150 deg. test oil used.

Wool, cotton, sand, asbestos and glass have all been tried for wicks; chemical treatment has been employed and the mechanical construction of wicks varied in the hope of reducing or eliminating crust. All kerosenes form crust when burning, no matter what the material of the wick, and a fair test considers the quality rather than the quantity of this crust.



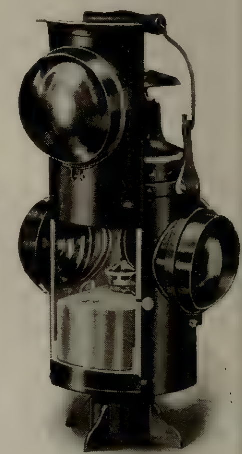
Train Order Lantern with Double Fresnel Lens.

Signal Lantern with Single Fresnel Lens.



Semaphore Lantern with Electric Burners.

Round Body Steel Lantern (Closed).



Round Body Steel Lantern (Top Draft).

Figs. 2675-2679. Switch and Signal Lanterns. Peter Gray & Sons.

A dry, brittle formation will crack at intervals and fall apart, leaving crevices through which the gas from the hot wick may escape, while a tarry crust will in short order completely seal up the top of a wick and extinguish the flame. Wicks have been impregnated with chemicals designed to cause disintegration of this crust, but the improvement has been slight, if any. The best results have been obtained by allowing the wick to fit as loosely as possible in its tube and by incorporating in the wick channels or cores parallel to its length.

R. S. A. SPECIFICATIONS FOR SIGNAL ROUNDELS, LENSES AND GLASS SIDES.

GENERAL.

Material.

All glasses must be of clear uniform solid color, containing the highest proportions of lead compatible with durability and securing the required color and must have a specific gravity of not less than 2.75. Chipped or flashed glasses will not be accepted.

Workmanship.

Workmanship shall be of the best, and glasses must be true to size and form, and practically free from bubbles, streaks, and wrinkles.

Color.

Red, green, yellow, blue, purple and lunar white glasses will be purchased.

Wrapping.

Each glass must be wrapped in paper of corresponding color.

Tests.

The manufacturer must test each glass, placing thereon a label showing the photometric value.

The purchaser reserves the right to make repetition of the above test, to insure that only material meeting the requirement is accepted, and all materials not meeting such requirements will be rejected. All red glasses must be submitted to the sodium test.

Samples.

The manufacturer must submit samples of glasses, showing the extreme limits of colors which it is proposed to furnish. These shall bear labels showing the photometric values, and if approved will be kept in the office of...................... as standards.

Rejected Material.

The purchaser will notify the manufacturer promptly as to rejected material, which will be retained not longer than two weeks from date of notification. If at the end of that time the manufacturer has not advised the purchaser as to disposition, such materials will be returned to the manufacturer at his risk, the manufacturer paying the freight both ways in either case.

ROUNDELS

Design.

Roundels must be of diameter specified in order, and between .21-inch and .29-inch thick.

Roundels will be subject to spectro-photometric analysis. The following table gives an analysis of roundels of the various colors of medium intensity, the letters indicating lines of the spectrum, and the figures showing percentages of light transmission at the different points. Roundels of medium intensity should transmit light as nearly as possible of this composition, a reasonable variation being allowed for light and dark limits.

	A	a	B	C	D	E	b	F	G	H
Red	60	65	70	72	0	0	0	0	0	0
Green	0	0	0	0	4	27	40	45	25	0
Yellow	0	38	50	43	41	12	9	3	0	0
Blue	0	0	0	0	3	4	6	24	40	46
Purple	0	42	42	0	0	0	0	2	43	42
Lunar White.........	0	62	49	17	15	25	38	65	74	0

Briefly describing the above photometric values.

Red.

Will be of such quality that all yellow rays of light are absorbed, the spectrum being either red or red and orange. The photometric value shall be, light 130, standard 100, dark 70.

Green.

Will be of the color known as Admiralty green, having a slightly bluish tint. The spectrum shall show very little yellow, being a full green with some blue. The photometric value shall be, light 125, standard 100, dark 75.

Yellow.

Will give a spectrum showing a full yellow band, most of the red and slightly of the green. The photometric value shall be, light 120, standard 100, dark 80.

Blue.

Will give a spectrum having a full blue band, with a narrow band of green. The photometric value shall be, light 125, standard 100, dark 75.

Purple.

Will give a spectrum showing a considerable proportion of both red and blue. The photometric value shall be light 125, standard 100, dark 75.

Lunar White.

Shall show a maximum of absorption for the yellow. The photometric value shall be, light 120, standard 100, dark 80.

LENSES.

The Railway Signal Association specifications for lenses are as follows:

Design.

All lenses must be of the optical pattern, focusing to a plane rather than to a point, and must be of the polyzonal type, with smooth outer face. All parts of the lens must focus to an area not exceeding ⅜ inches in diameter for all lenses up to the six-inch size, nor exceeding ½ inch in diameter for the larger sizes; must be so designed that the divergence of the projected beam (i. e. spread), with flame one inch broad, shall not exceed one foot from the axis in eight feet. When observed at a distance of 30 or 40 feet, a small flame oil burner being placed in the focus, the whole lens shall be equally illuminated, the "risers" on the inner surface showing only as narrow dark rings.

All lenses 6⅝ inches and over diameter must have at least five zones, and the smaller lenses four, and must be corrugated inside.

Color.

Colored corrugated lenses must have the same photometric and spectro-photometric values as roundels of the same color, but allowance will be made for divergences due to irregularities of manufacture.

Focus.

The focus of each lens must be stamped on the outer zone.

GLASS SLIDES.

The Railway Signal Association specifications for glass slides are as follows:

Material.

The glass must be double thick, and of the same character of material as furnished for lenses and roundels. Thickness of slides shall be not less than .095 inch and not more than .15 inch.

Design.

Slides must be cut or pressed to size ordered.

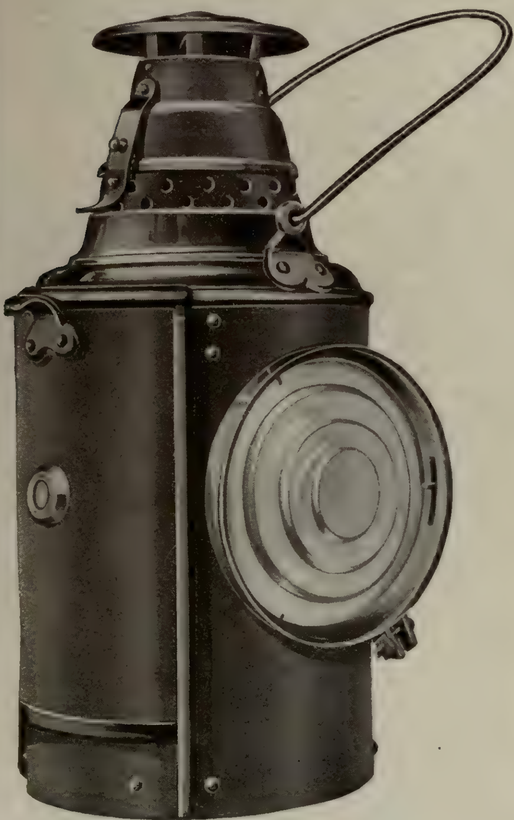
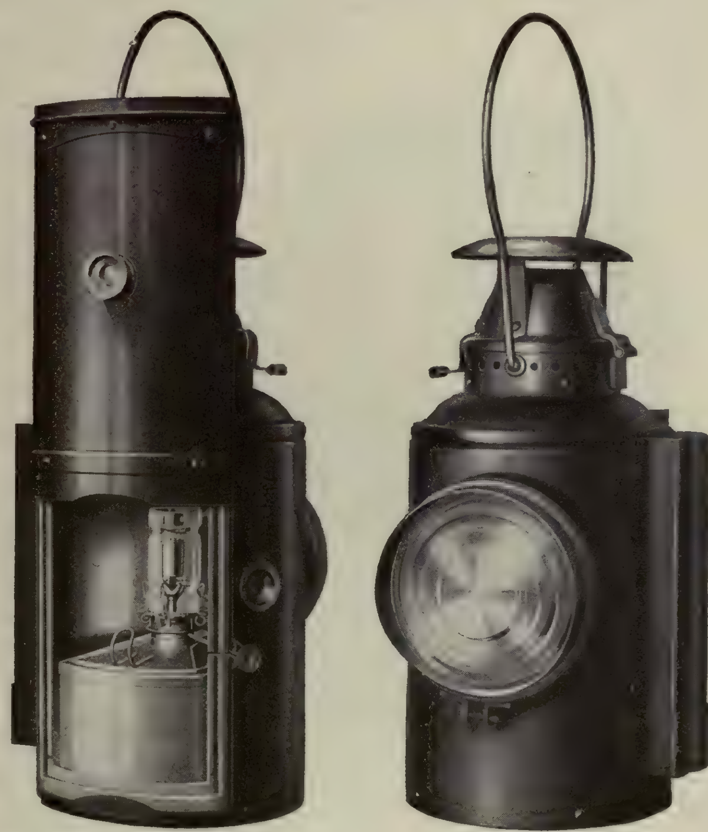
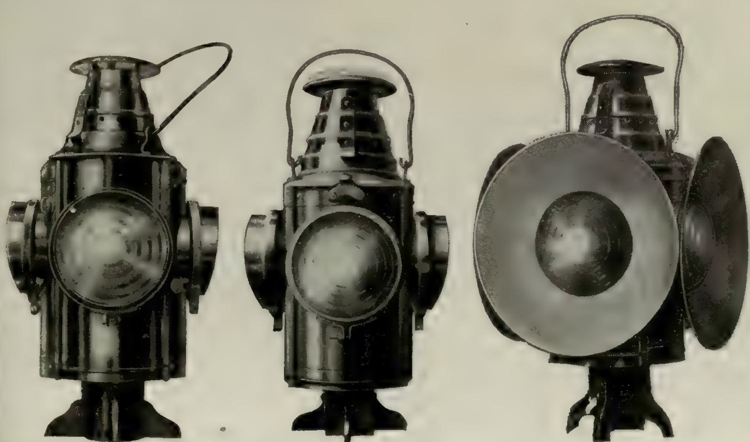


Fig. 2680. Semaphore Lantern. Dressel Railway Lamps Works.



Figs. 2681-2682. Semaphore Lamps Equipped with Long Time Burners. The Adams & Westlake Company.

[Note.—The Long Time Burner Shown in Fig. 2681 is Shown in Detail in Fig. 2701.]



Figs. 2683-2685. Steel Switch Lamps. Dressel Railway Lamp Works.

Fig. 2686. Semaphore Lamp. Dressel Railway Lamp Works.

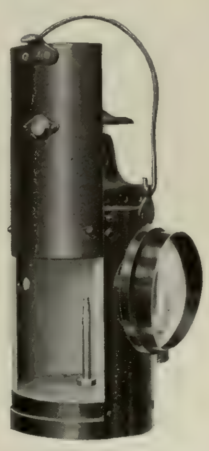
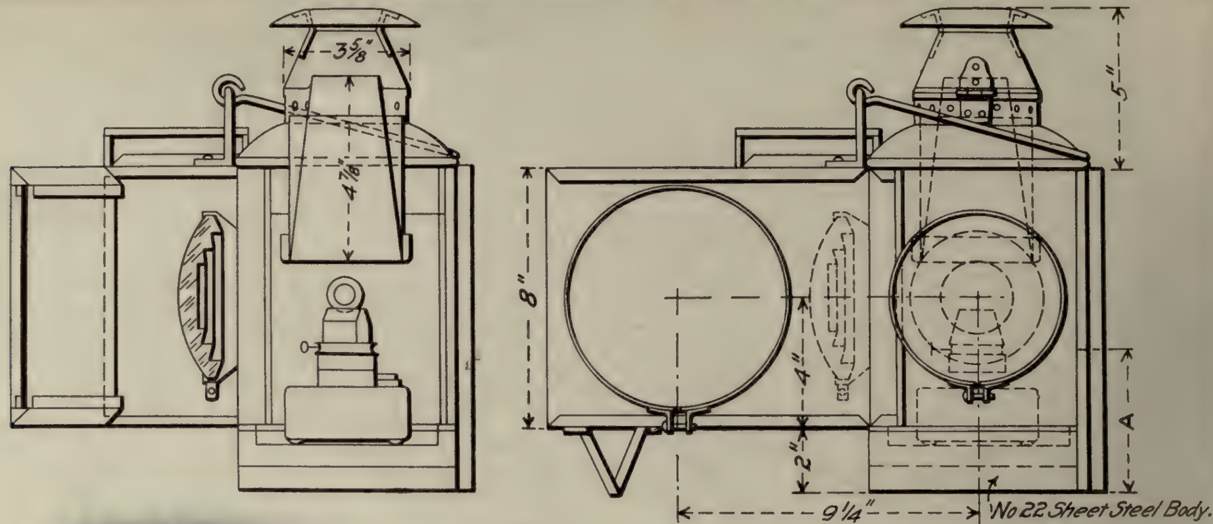
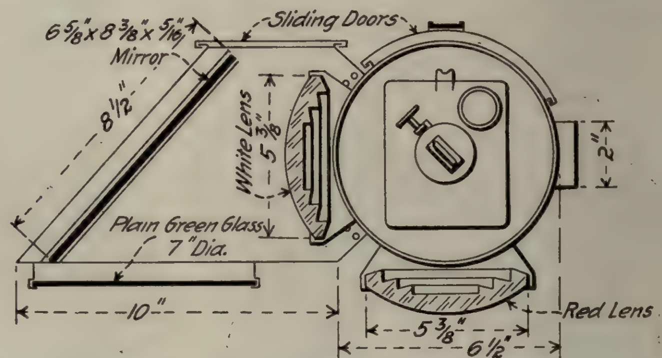


Fig. 2687. Semaphore Lantern with Acetylene Burner. Peter Gray & Sons.





Figs. 2688-2690. Distant Signal Lamp. Chicago & North-Western.

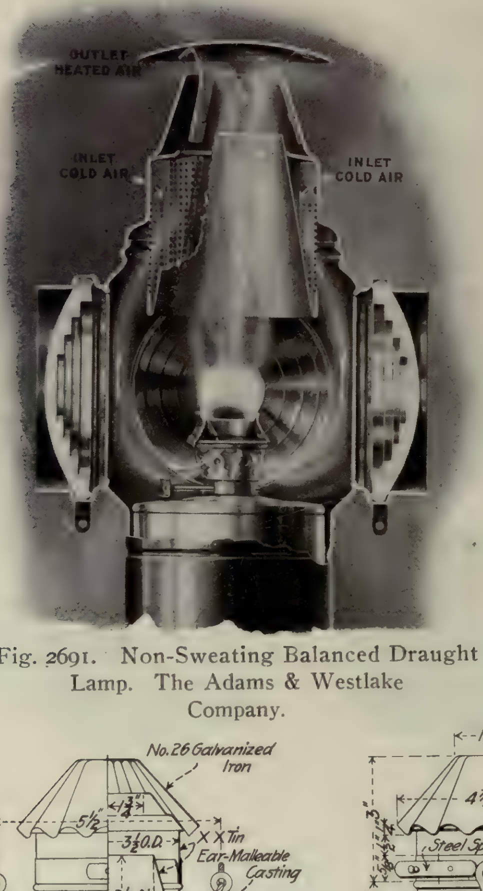


Fig. 2691. Non-Sweating Balanced Draught Lamp. The Adams & Westlake Company.

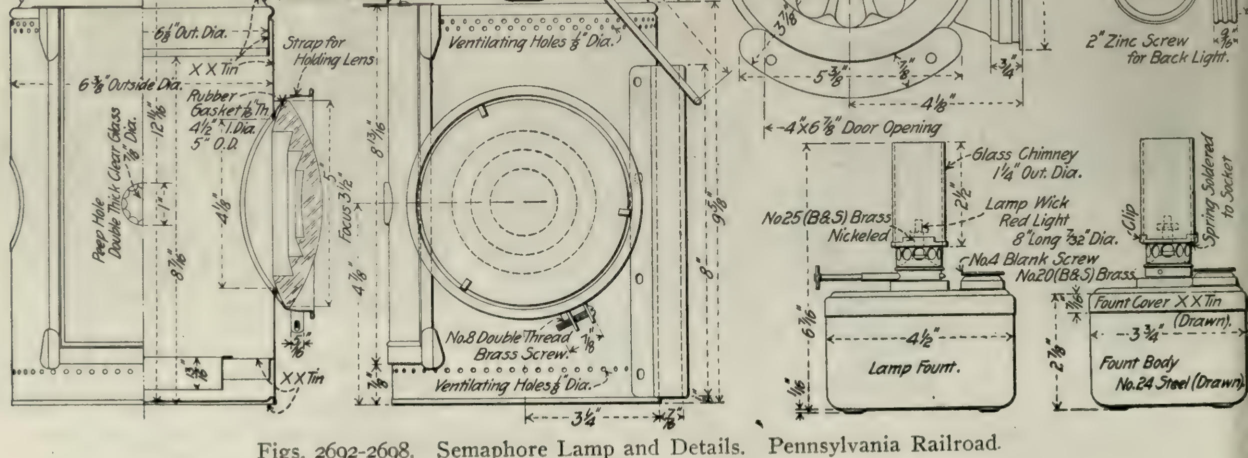
ADLAKE NON-SWEATING BALANCED DRAUGHT.

Adlake non-sweating balanced draught lamps are designed to eliminate precipitation of moisture or "sweating," irrespective of varying temperatures or wind pressure. The accomplishment of this result secures three important ends:

1st—Lenses are kept clear and no moisture, frost or ice retards the passage of light.

2d—The corrosion of lamp bodies is prevented.

3d—The burner flame is fully protected to withstand severe winds. All types of lamps can be equipped with this ventilation.



Figs. 2692-2698. Semaphore Lamp and Details. Pennsylvania Railroad.

Fig. 2699. Long Burning Fount with Prism Glass Reflector. The Adams & Westlake Company.

Fig. 2700. Long Burning Fount with One-way Metallic Reflector. The Adams & Westlake Company.

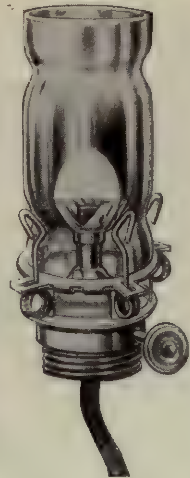
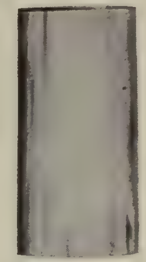
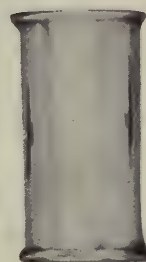
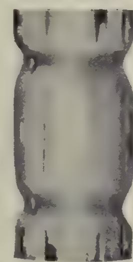


Fig. 2701. Long Time Burner. The Adams & Westlake Company.







Figs. 2702-2705. Chimneys.

Fig. 2706. 20-Oz. (One Day) Oil Fount. The Adams & Westlake Company.

Fig. 2707. 31-Oz. Oil Fount. Dressel Railway Lamp Works.

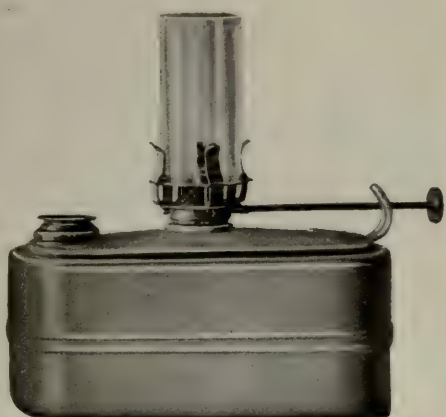


Fig. 2708. Drawn Steel Oil Fount. 31-Oz.

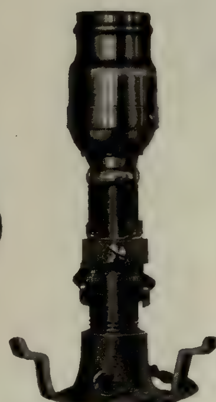


Fig. 2709. Electric Top Socket. Dressel Railway Lamp Works.

Fig. 2710. Base and Burner of Chimneyless Burner. Peter Gray & Sons.

Fig. 2711. Steel Flame Spreader Detached from Base of Chimneyless Burner. Peter Gray & Sons.

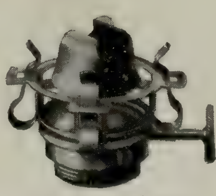


Fig. 2712. Long Time Burner. Dressel Railway Lamp Works.

Fig. 2713. 32-Ounce One Piece Fount with Chimneyless Burner for Switch and Semaphore Lanterns. Also Made in 20-oz. Size. Peter Gray & Sons.

Fig. 2714. Chimneyless Burner Complete. Peter Gray & Sons.

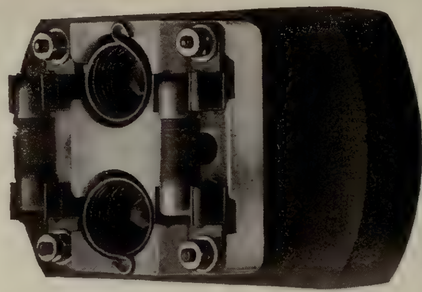


Fig. 2715. Electric Socket. Dressel Railway Lamp Works.

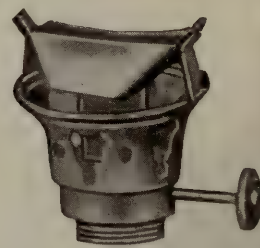


Fig. 2716. Twenty-four Hour Burner. Adams & Westlake Company.

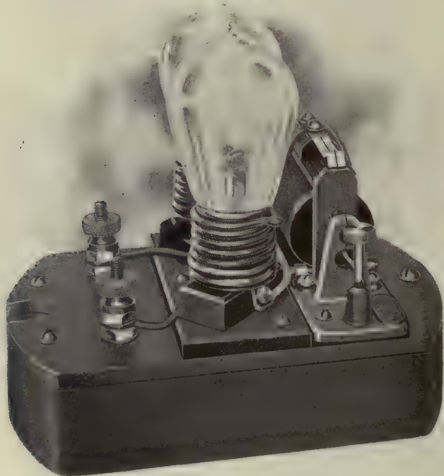


Fig. 2717. Electric Lights for Signal Lanterns. One Bulb in Circuit; Other Automatically Thrown in Circuit if First Fails. Peter Gray & Sons.

Fig. 2718. Electric Lamp for Semaphore Lamp. The Adams & Westlake Company.

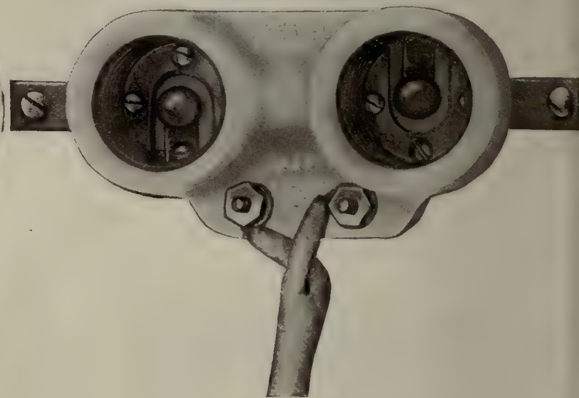


Fig. 2719. Electric Back Socket. Dressel Railway Lamp Works.

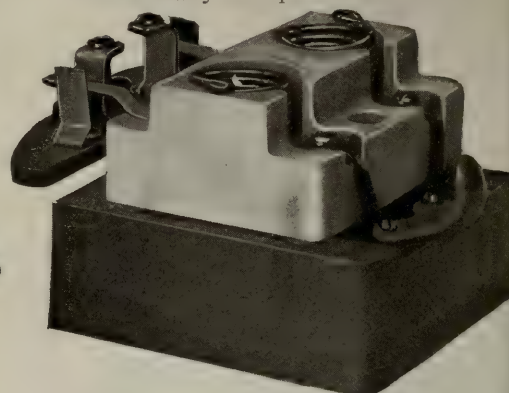


Fig. 2720. Electric Socket. Dressel Railway Lamp Works.

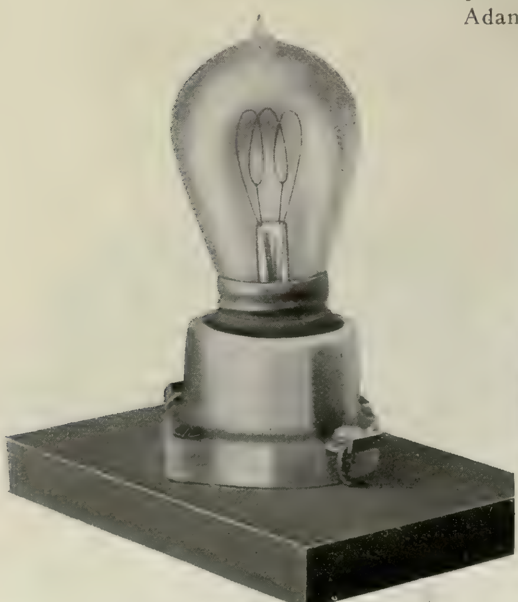


Fig. 2721. Electric Light Burner. The Adams & Westlake Company.

Fig. 2722. Long - Burning Fount with Reflector. Dressel Railway Lamp Works.

Fig. 2723. Long - Burning Fount. Dressel Railway Lamp Works.

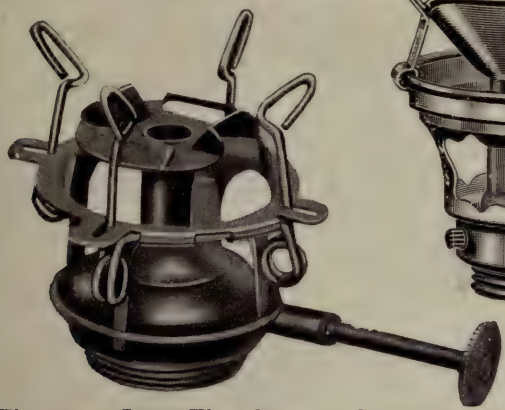


Fig. 2724. Long-Time Burner. The Adams & Westlake Company.

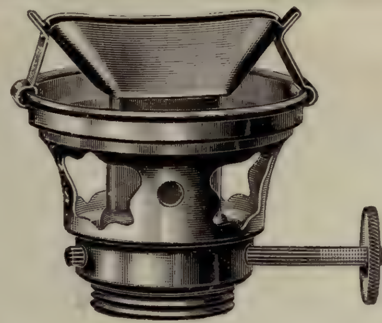


Fig. 2725. No. 1 Low Dressel Burner. Dressel Railway Lamp Works.

Fig. 2727. Train Order Semaphore Lamp. The Adams & Westlake Company.

Fig. 2726. Twenty-four Hour Burner. Dressel Railway Lamp Works.

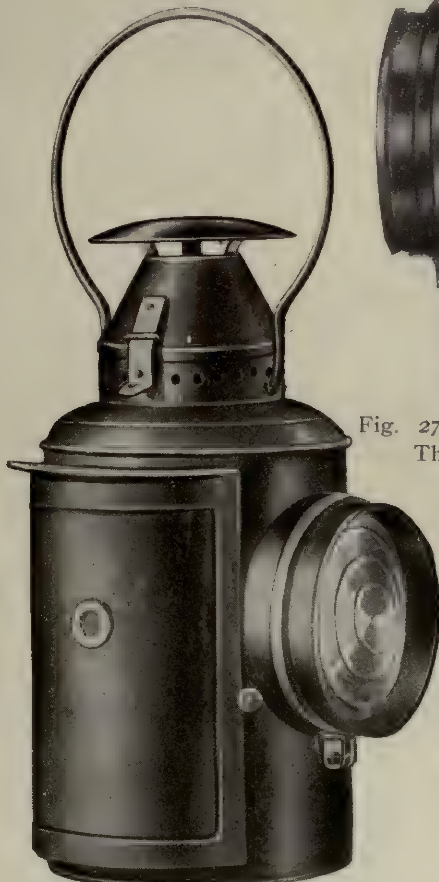


Fig. 2729. Semaphore Lamp. The Adams & Westlake Company.

Fig. 2728. Convertible Semaphore Lamp. The Adams & Westlake Company.

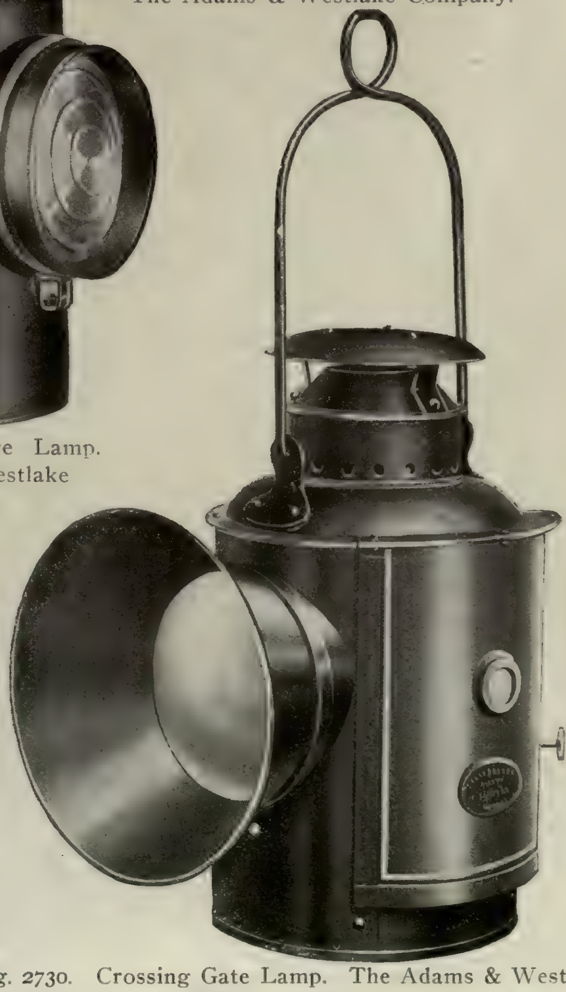
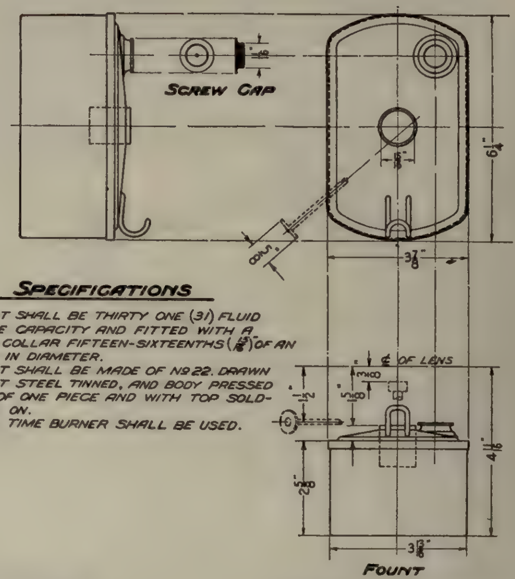


Fig. 2730. Crossing Gate Lamp. The Adams & Westlake Company.

Fig. 2731. Pier or Abutment Lamp. The Adams & Westlake Company.



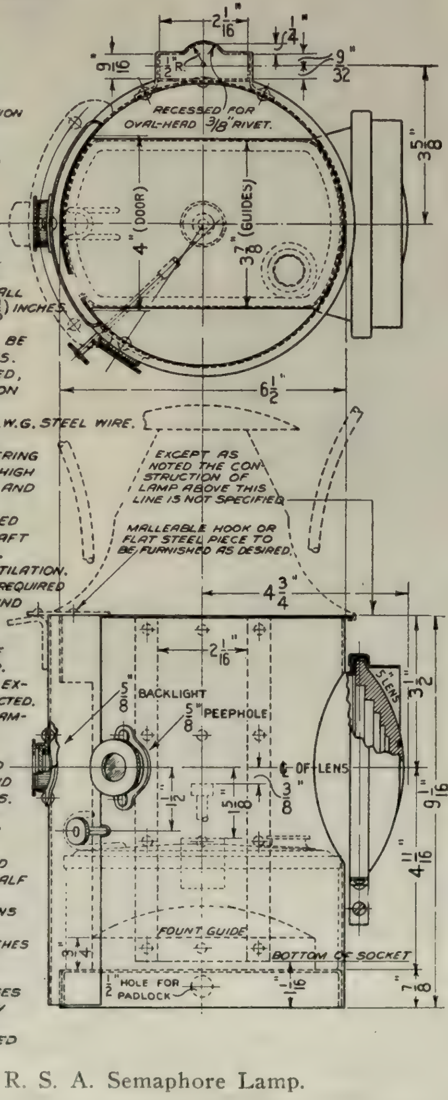
SPECIFICATIONS

1. FOUNT SHALL BE THIRTY ONE (31) FLUID OUNCE CAPACITY AND FITTED WITH A SLIP COLLAR FIFTEEN-SIXTEENTHS ($\frac{15}{16}$) OF AN INCH IN DIAMETER.
2. FOUNT SHALL BE MADE OF NO 22. DRAWN SHEET STEEL TINNED, AND BODY PRESSED OUT OF ONE PIECE AND WITH TOP SOLDERED ON.
3. LONG TIME BURNER SHALL BE USED.

Fig. 2734. R. S. A. Lamp Equipment.

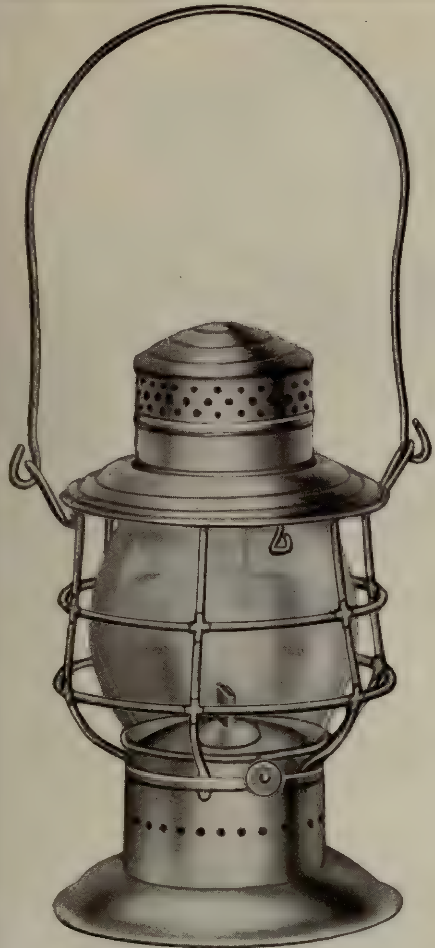
SPECIFICATIONS

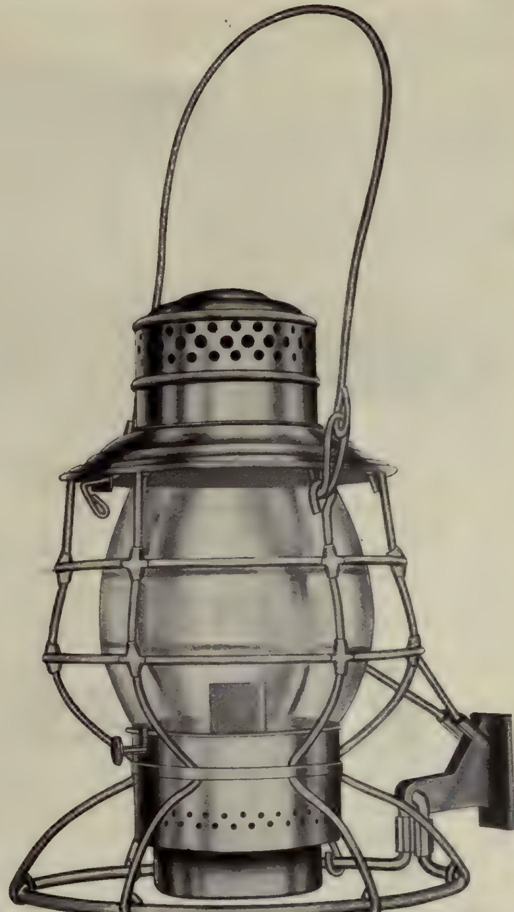
1 BODY OF LAMP SHALL BE MADE OF NO. 18. SHEET STEEL TINNED.
2 BODY OF LAMP SHALL BE SIX AND ONE-HALF ($6\frac{1}{2}$) INCHES IN DIAMETER.
3 RIVETS SHALL BE USED IN CONSTRUCTION OF THE BODY OF THE LAMP FOR HOLDING PARTS TOGETHER.
4 DISTANCE FROM CENTRE OF LAMP TO OUTSIDE OF LENS, OR LENS SHIELD, SHALL BE NOT MORE THAN FOUR AND THREE-FOURTHS ($4\frac{3}{4}$) INCHES.
5 DISTANCE FROM CENTRE OF LENS TO BASE OF LAMP SHALL BE FIVE AND NINE-SIXTEENTHS ($5\frac{9}{16}$) INCHES.
6 DISTANCE FROM CENTRE OF LENS TO BOTTOM SUPPORT OF FOUNT SHALL BE FOUR AND ELEVEN-SIXTEENTHS ($4\frac{11}{16}$) INCHES.
7 DISTANCE FROM CENTRE OF LAMP TO CENTRE OF LAMP SOCKET SHALL BE THREE AND FIVE-EIGHTHS ($3\frac{5}{8}$) INCHES.
8 EARS OR BAIL HOOKS, WHERE USED, SHALL BE MADE OF MALLEABLE IRON RIVETED TO BODY OF LAMP.
9 HANDLE OF LAMP SHALL BE NO. 4. B.W.G. STEEL WIRE.
0 DOOR SHALL HAVE WATER-SHED SO ARRANGED AS TO PREVENT RAIN ENTERING THE LAMP, AND DOOR SHALL RAISE HIGH ENOUGH TO MAKE THE OPENING SIX AND FIVE-EIGHTHS ($6\frac{5}{8}$) INCHES.
11 LAMP SHALL BE SO CONSTRUCTED THAT THE WICK ADJUSTMENT SHAFT EXTENDS THROUGH BODY OF LAMP.
12 LAMP SHALL HAVE TOP DRAUGHT VENTILATION. (VENTILATION WILL BE TESTED WHEN REQUIRED AT THE FACTORY AS FOLLOWS. (A) WIND VELOCITY EQUIVALENT TO EIGHTY (80) M.P.H. FOR TWO (2) MINUTES. (B) STILL AIR- TEMPERATURE ONE HUNDRED AND TEN (110) DEGREES FAHR. FOR TWO (2) HOURS. IF ABOVE TESTS EXTINGUISHES FLAME LAMP WILL BE REJECTED.
13 LENS SHALL BE FIVE (5) INCHES IN DIAMETER WITH THREE AND ONE-HALF ($3\frac{1}{2}$) INCH FOCUS.
14 LENS HOLDER SHALL BE ARRANGED SO THAT LENS CAN BE EASILY REMOVED AND SHALL COMPLETELY ENCIRCLE THE LENS.
15 LAMP SHALL BE PROVIDED WITH FIVE-EIGHTHS ($\frac{5}{8}$) INCH BACK-LIGHT WITH ONE (1) INCH SCREW CAP.
16 SOCKET OF LAMP SHALL BE ARRANGED TO RECEIVE A LAMP BRACKET ONE-HALF BY TWO ($\frac{1}{2}$ x 2) INCH DIMENSIONS. SOCKET NOT TO EXCEED THE DIMENSIONS OF BRACKET MORE THAN ONE-SIXTEENTH ($\frac{1}{16}$) INCH AND BE EIGHT (8) INCHES IN DEPTH, RECESSED FOR (OVAL-HEAD) THREE-EIGHTHS ($\frac{3}{8}$) INCH RIVET.
17 BACK-LIGHT AND PEEP-HOLE GLASSES SHALL BE HELD IN PLACE BY SCREW RETAINING RINGS.
18 INSECT SCREEN SHALL BE PROVIDED WHEN SPECIFIED.



Figs. 2732-2733. R. S. A. Semaphore Lamp.

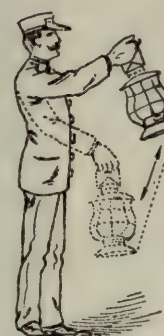
Fig. 2735. Standard Lantern. The Adams & Westlake Company.





Figs. 2736-2737. Standard Railroad Lanterns. The Adams & Westlake Company.

Stop—Swung Across the Track.



Go Ahead—Raised and lowered. the man facing toward the person to whom the signal is given.

Back—Swung vertically in a circle at half arm's length across the track.

Train Has Parted—Swung vertically in a circle at arm's length across the track.

Apply Air-Brakes—Swung horizontally in a circle.

Release Air-Brakes—Held at arm's length above the head.

Figs. 2738-2743. Hand Signals. To be given with Hand or Lantern.

LIGHTNING ARRESTERS

UNION SPARK GAP LIGHTNING ARRESTER.

The arrester illustrated in Fig. 2746 consists of two electrodes separated by a spark gap and carried by a supporting plate drilled so that it may be slipped across the terminals of the relay coils (see Fig. 2744) so that no wires are required to connect it in circuit. This arrester acts as a shunt across the coil terminals, which becomes effective only when the potential rises to an abnormal amount.

Figs. 2744-2745. Brass Plate and Glass Tube Types of Spark Gap Lightning Arresters. The Union Switch & Signal Company.

It is built in two forms: One in which the electrodes consist of two thin brass plates, separated by the proper air gap and bent away from the supporting plate at the air gap so as to avoid the accumulation of dirt at this point (Fig. 2745);

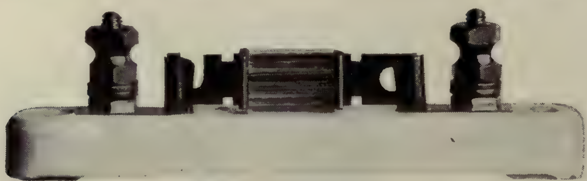


Fig. 2746. Spark Gap Lightning Arrester Mounted. The Union Switch & Signal Company.

and the other in which ordinary pins carried by small glass tubes are the electrodes, three of which units are carried on each side of the supporting plate. The first type with brass plate electrodes has the advantage of extreme simplicity and will withstand any number of discharges without increase of air gap due to the burning action of the spark. The other type with pin electrodes is more sensitive to discharges than the brass plate form, as it is a well known fact that point electrodes will discharge at a lower potential than blunt ones, although of necessity the point electrodes are more affected by the burning action of the discharge. However, the glass tube arrester may be depended upon to carry several hundred ordinary discharges before showing a decrease in sensitiveness due to increase in the spark gap. This type of arrester may be mounted on either the 9-C or Universal relay.

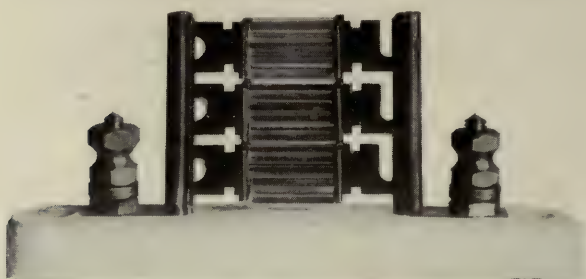


Fig. 2747. Spark Gap Arrester for Line Service. The Union Switch & Signal Company.

G. R. S. LIGHTNING ARRESTER.

Fig. 2748 illustrates the G. R. S. Co.'s Model I Form A lightning arrester, designed for use on signal, telegraph, telephone and crossing alarm circuits. The arrester has a high efficiency, i. e., a high reactance and negligible ohmic resistance. This high reactance is maintained under all conditions of frequency and current, owing to the fact that no iron is used in the core of the reactance coil.

The arrester is small (15/16 in. x 4¾ in. x 3¾ in.), and may be assembled in banks on 15/16 in. centers. Connectors between the ground plates are provided, which form a bus-bar of ample carrying capacity, thereby making requisite but one ground connection for any number of arresters. Multiple point discharge plates are provided instead of the single point type or one having a circular surface. No delicate or easily broken parts are used in the arrester construction. The connections are all in front for easy inspection and installation

The Model I Form A uses the same component parts as the Model I arrester.

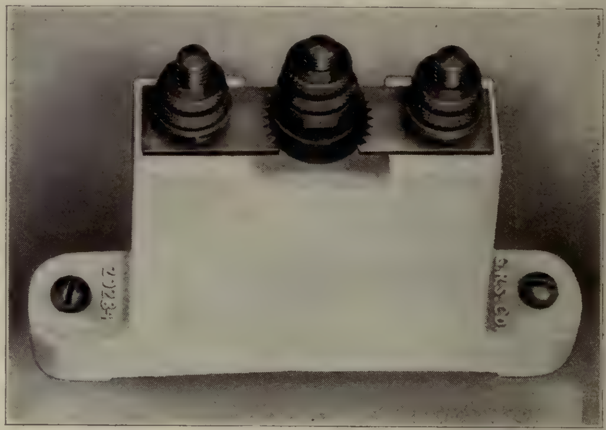


Fig. 2748. Model 1, Form "A" Lightning Arrester. General Railway Signal Company.

GENERAL ELECTRIC DIRECT CURRENT LIGHTNING ARRESTER.

The General Electric Type M Form D-2 arrester is furnished for circuits from 60 to 800 volts. The spark gap and non-inductive resistance are in a straight line, thus forming a direct

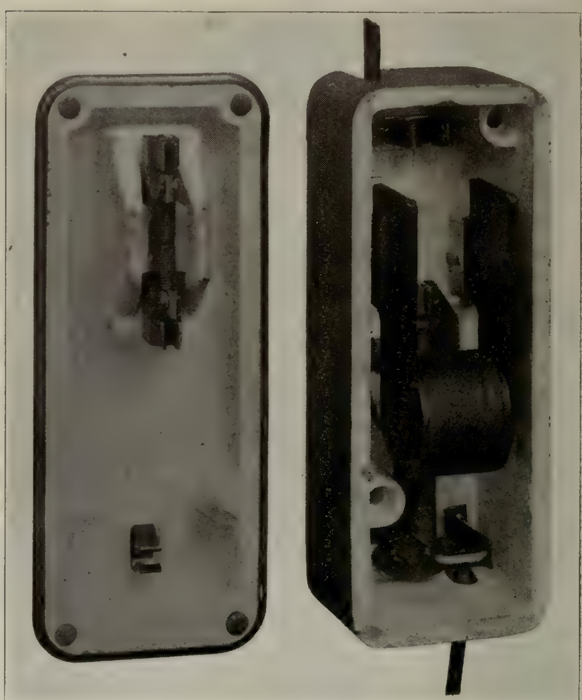


Fig. 2749. Type "M" Form D-2. Lightning Arrester. General Electric Company.

path for the discharge and reducing to a minimum the possibility of short circuit in the box in case of excessively heavy lightning discharges. All parts can be readily inspected on removing the cover of the porcelain enclosing box, and a glance will show if the arrester is in proper condition for the next storm.

THE ARC DAMP ARRESTER.

The Arc Damp lightning arrester, made by the P. & M. Co., is designed for either alternating or direct current circuits. It consists of a porcelain shield or box, the over-all dimensions, including binding posts, being: length, 4⅞ in.; width, 1 11-16 in.; height, 3½ in.

It has an air gap of fixed dimensions, in series with a disc or block of special composition which serves to dampen the

Fig. 2750. The Arc Damp Lightning Arrester. P. & M. Company.

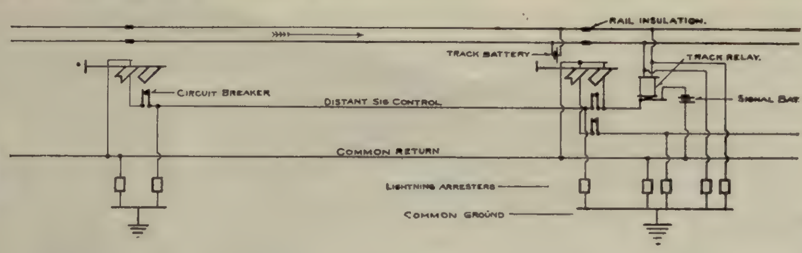


Fig. 2751. Lightning Arresters Applied to Block Signal Apparatus.

arc in the air gap and prevent the working current from following the lightning discharge current. The arrester is intended for use on circuits having a working voltage of 250 volts or less. To this voltage it is essentially an open circuit, there is no leakage of current through it and no mutual interference of signal circuits. To a lightning discharge, however, it offers a ready path to earth at a voltage well below that necessary to break down the insulation resistance of fairly well built magnets. The capacity is ample for carrying off the charge of ordinary signal circuits.

The area and length of the air gap—a hole punched in a sheet of mica—is not only protected from outside interference, but is essentially sealed against a renewal of oxygen after the arc has started. This feature, together with the peculiar damping effect of the composition block or disc, makes it essentially impossible, short of the destruction of the arrester as a whole, to fuse together the brass discs which form the walls of the air gap.

Lightning trouble has been experienced with installations where distant signals are controlled without the use of line wires, no wires being used except for the local circuits at signal locations. The most reliable evidence seems to indicate that trouble is caused by a static difference of potential between the rails of the track circuit and the earth, the disruptive discharge taking place through the track relay, the signal control magnet, and thence to earth. In this case the remedy would be to apply an arrester to each wire which connects the relay coil to the track rail. Trouble of this character can be overcome by the proper application of the arrester, the most difficult part usually being in the correct diagnosis of the condition.

A common ground may be used for all arresters in a signal tower, at a signal location, or at any other place where a number of arresters are bunched. An exception to this is where arresters are used on circuits having a wide difference of working voltage, such as 500 volts or over on the one hand and 110 or under on the other. The reason for this is the possibility of a defective ground connection causing a discharge from a circuit of higher voltage to a circuit of lower voltage.

If a ground plate is desired it may be made of a tinned copper plate $\frac{1}{16}$ in. thick by 18 in. square, to which is soldered a No. 6 B. & S. gauge tinned copper wire about 10 ft. long. This plate should be buried in a hole dug deep enough to reach permanently moist earth. The plate should be surrounded by a liberal quantity of crushed charcoal or coke. This material is a conductor and, being hygroscopic, absorbs and retains moisture and multiplies the area of contact between the plate and earth. Engine smoke-box cinders are good and are usually convenient for the purpose.

Magnetic material such as iron or steel should not be used as a part of the conductor in securing a ground. A steel rail, for instance, offers more than 10 times the impedance to alternating current of 60 cycles that it does to direct current. As the impedance increases with the frequency, it is evident that a rail would be a poor conductor for a current having the very high frequency of a lightning discharge.

Connecting to a piece of iron pipe driven into the ground is open to the objection that the pipe, even if galvanized, will soon be coated with insulating rust, and the character of the ground into which it is driven is often unknown or not considered, and it has not the benefit of coke or charcoal.

An independent ground plate has the advantage of being un-

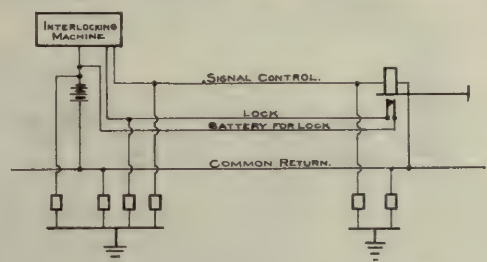


Fig. 2752. Lightning Arresters Applied to Interlocking Apparatus.

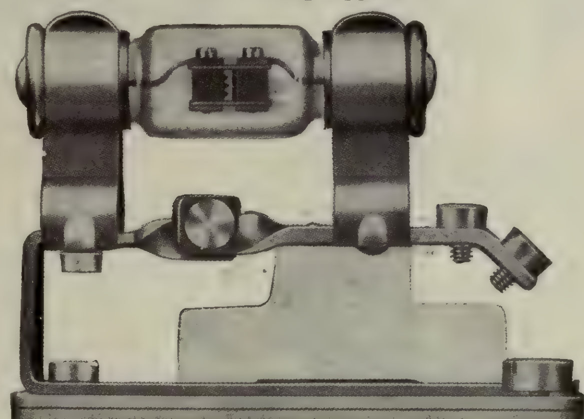


Fig. 2754. Siemens & Halske Vacuum Lightning Arrester. United States Electric Company.

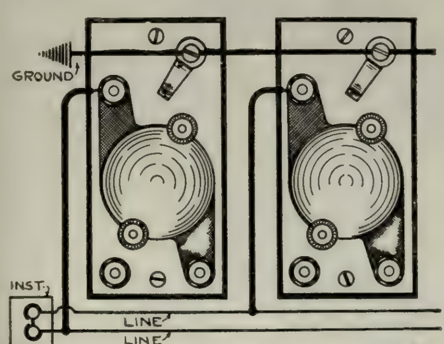


Fig. 2753. Carbon Lightning Arresters in Parallel with Instrument to be Protected. Railroad Supply Company.

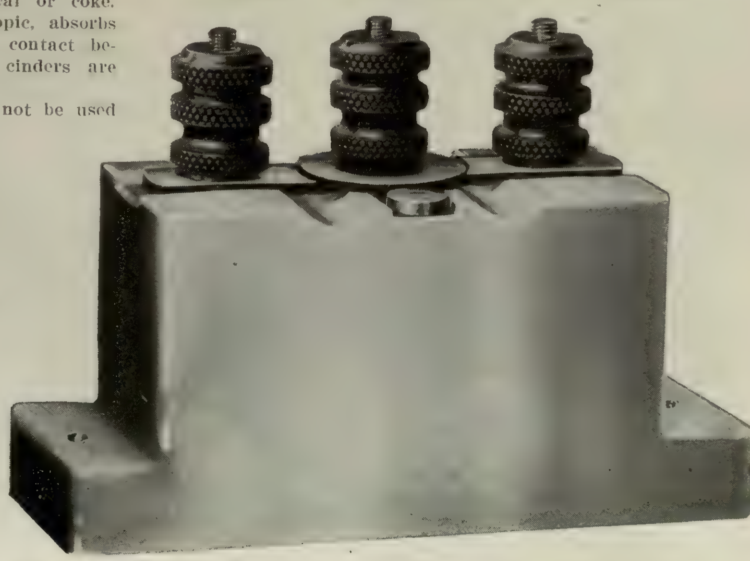


Fig. 2755. Premier Lightning Arrester. Bryant Zinc Company.

disturbed by changes or renewals in other apparatus, such as would be the case were connections made to rails, pipes, etc. The resistance between ground plate and earth should not exceed 50 ohms.

Fig. 2751 shows how lightning arresters of the arc damp type are applied to protect block signal apparatus; and Fig. 2752 shows these arresters applied to the protection of interlocking apparatus.

Figs. 2765-2767 show the details of the ground plate, such as above mentioned. Fig. 2788 shows the method of installing the Paragon ground cone, which is designed as a substitute for the ground plate.

PREMIER LIGHTNING ARRESTER.

Figs. 2759-2760 show the Premier lightning arrester made by the Bryant Zinc Co.

A carbon ground plate is placed between two toothed brass spark plates, and two double-wound choke coils are used, which give a decided choking effect. The different parts of this arrester are contained in separate pockets, cast in a solid porcelain block.

G. E. ALTERNATING CURRENT ARRESTERS.

The spark gap type arrester, known as "Form D," consists of a row of metal cylinders, spaced with a small air gap between them and connected between line and ground.

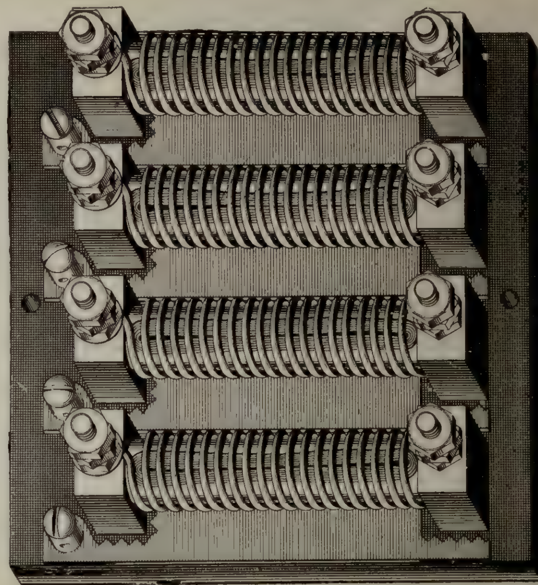


Fig. 2764. Four-Point Choke Coil Lightning Arrester. Railroad Supply Company.

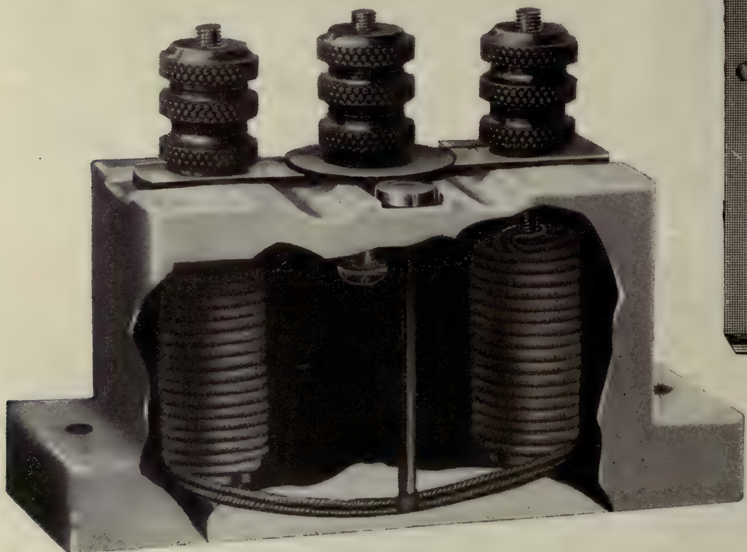


Fig. 2760. Premier Lightning Arrester. Bryant Zinc Company

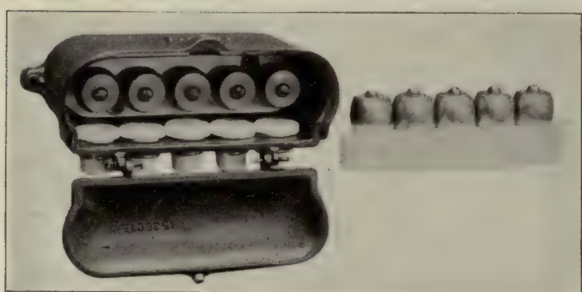
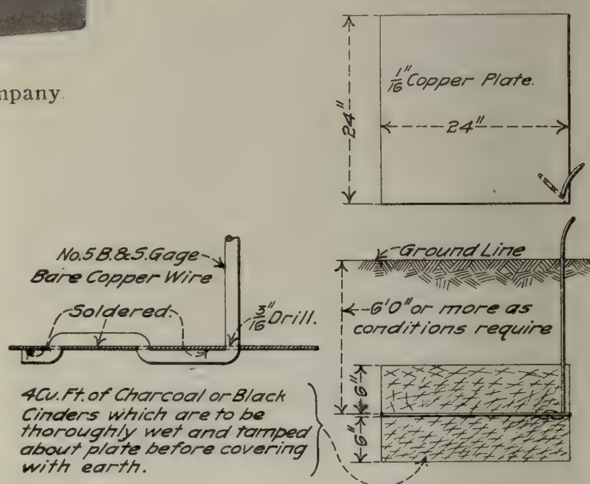


Fig. 2761. Triple Pole, 300-Volt Lightning Arrester. General Electric Company.



Figs. 2765-2767. Ground Plates and Details.

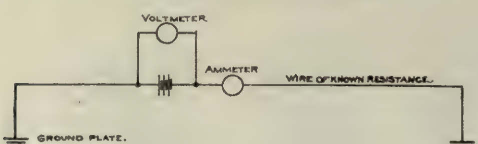


Fig. 2762. Method of Testing for Resistance of Ground Connection. (Assuming Resistance of Earth to be Zero.)

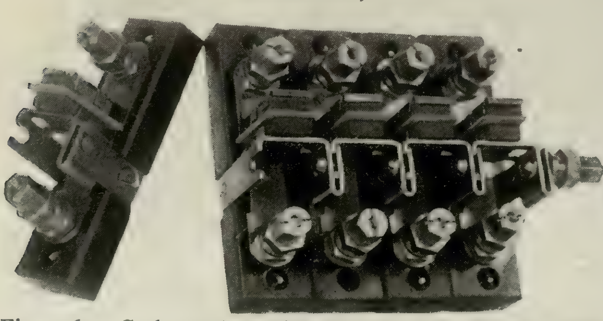


Fig. 2763. Carborundum Lightning Arrester. L. S. Brach Supply Company.

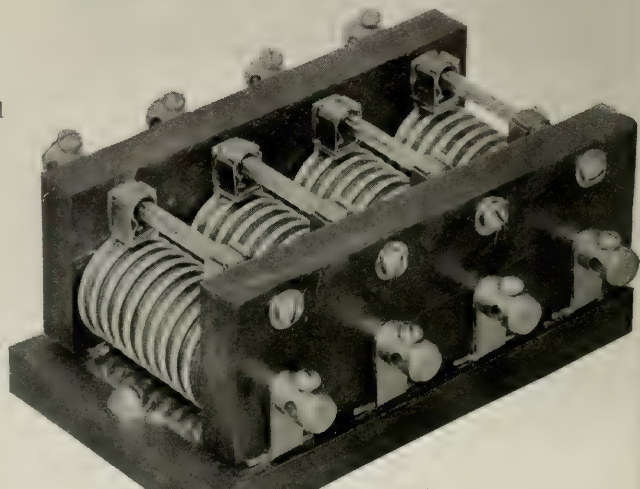


Fig. 2768. Lightning Arrester. General Electric Company.

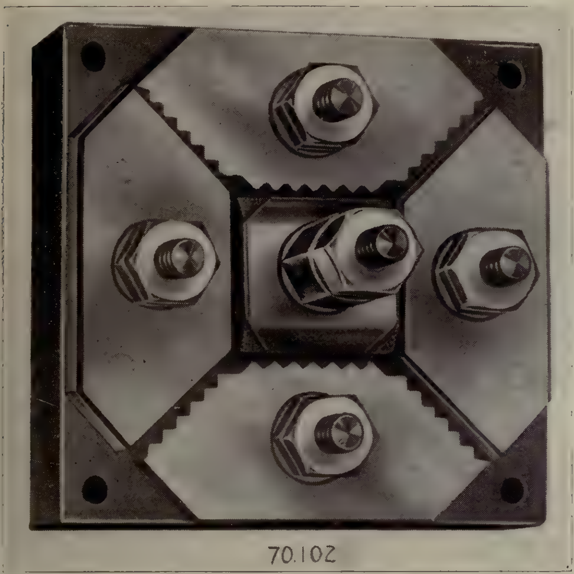


Fig. 2769. Lightning Arrester. New York Central. Hall Signal Company.

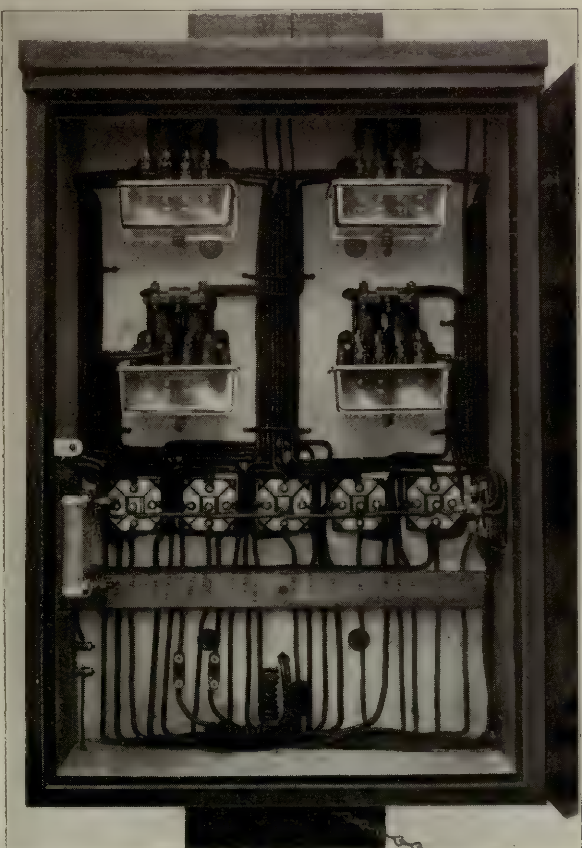


Fig. 2770. Lightning Arresters in Relay Box. Hall Signal Company.

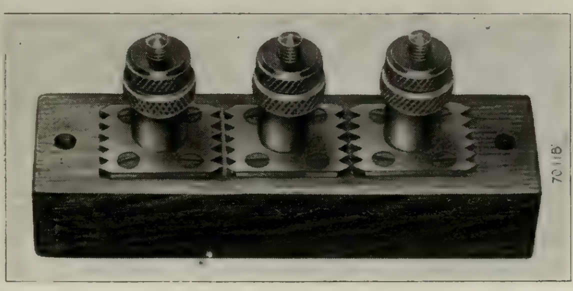


Fig. 2771. Lightning Arrester, Style "H." Hall Signal Company.

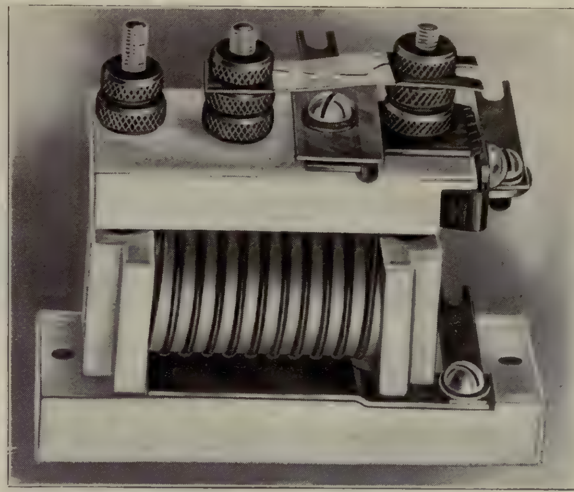


Fig. 2772. Lightning Arrester, Style "E-G." Hall Signal Company.

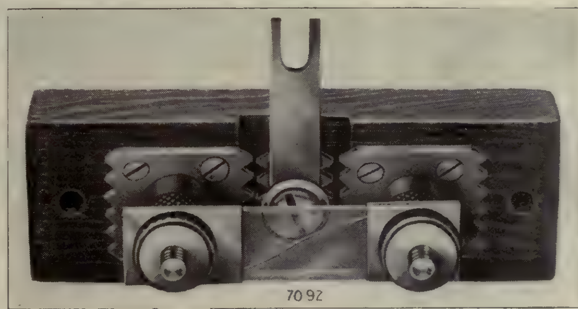


Fig. 2773. Lightning Arresters, Style "W." Hall Signal Company.

HALL LIGHTNING ARRESTERS.

Fig. 2769 shows "NYC" style lightning arrester made by the Hall Signal Co.; Fig. 2770 shows a number of these arresters as installed in a relay box; Fig. 2771 illustrates the Style "H" arrester; Fig. 2772 shows the style "EG"; and Fig. 2773 illustrates the Hall Style "W" arrester.

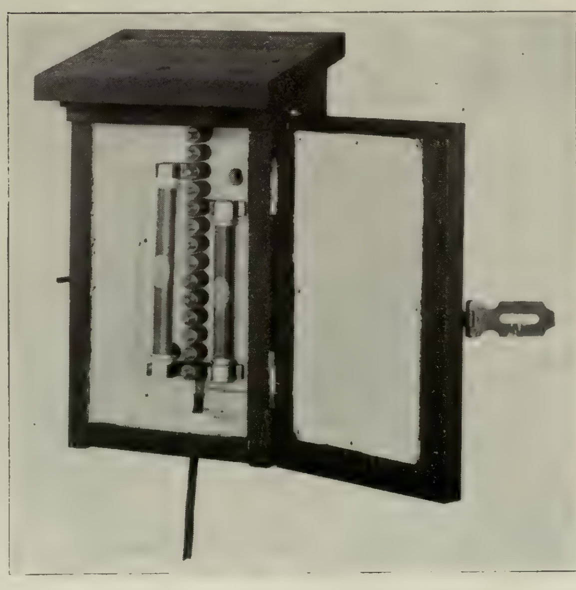


Fig. 2774. 2300-Volt Lightning Arrester for Line Service. General Electric Company.

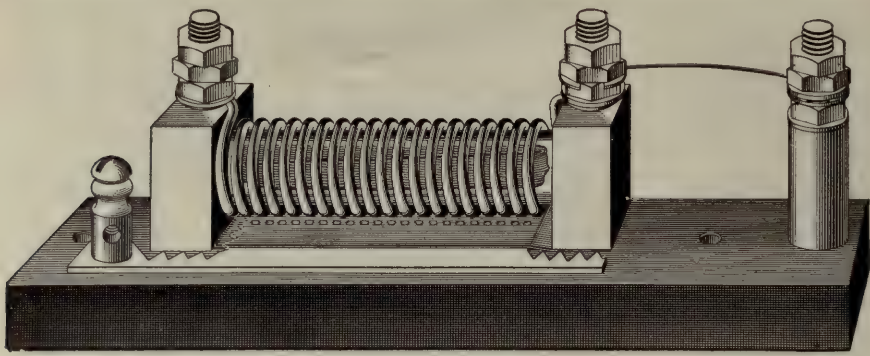


Fig. 2775. Style "B" Lightning Arrester. Railroad Supply Company.

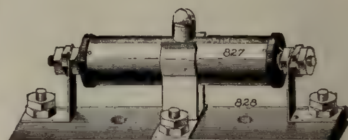


Fig. 2776. Enclosed Lightning Arrester Mounted on Slate Base. Railroad Supply Company.

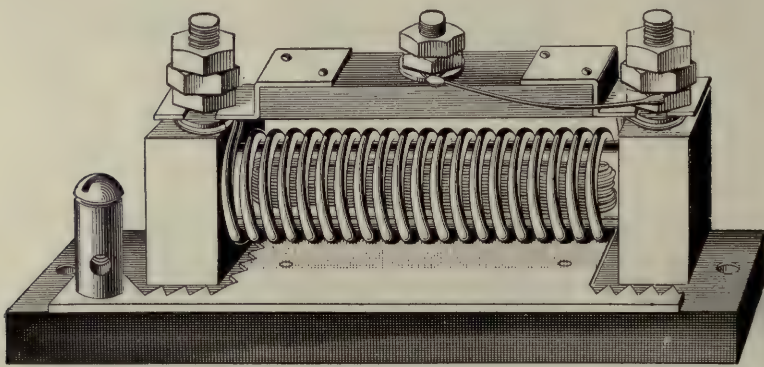


Fig. 2778. Style "C" Lightning Arrester, with Fuse Block and Fuse. Railroad Supply Company.

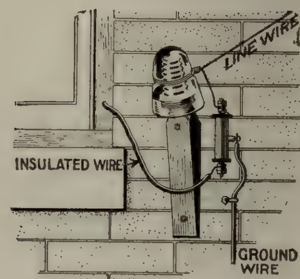


Fig. 2777. Application of Enclosed Lightning Arrester. Railroad Supply Company.

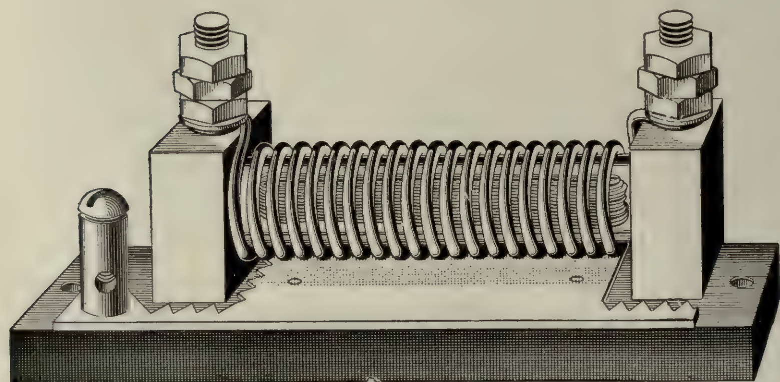


Fig. 2779. Style "A" Lightning Arrester. Railroad Supply Company.

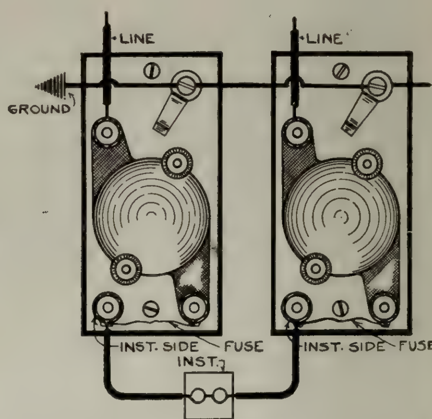


Fig. 2780. Style "F" Arresters in Series with Instrument to be Protected. Railroad Supply Company.

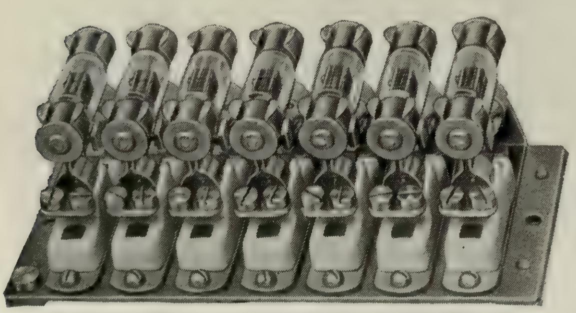


Fig. 2781. Bank of Vacuum Arresters. United States Electric Company.

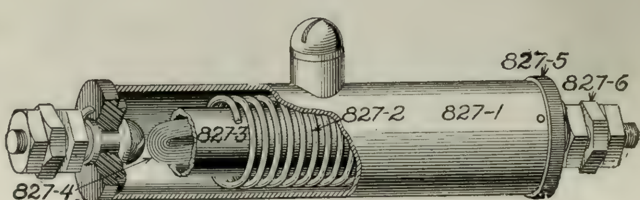


Fig. 2782. Part Sectional View of Enclosed Lightning Arrester. Railroad Supply Company.

PARAGON GROUND CONE.

The Paragon ground cone is a grounding device made by the Paragon Sellers Co. which consists of a hollow perforated cone of pure copper filled with charcoal or coke. The charcoal or coke constantly attracts moisture, keeping the earth damp around the cone, and the perforations—75 to the sq. in.—furnish an ample number of discharge points.

The cone is easily installed, as it is only necessary to bore a post hole and drop the cone in.

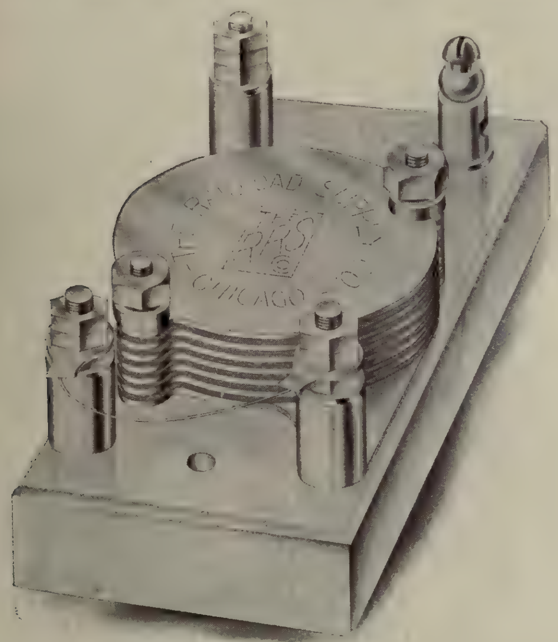


Fig. 2783. Style "F" Lightning Arrester. Railroad Supply Company.

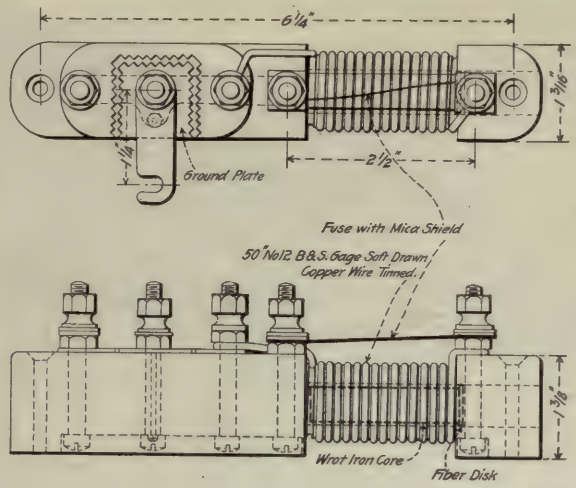


Fig. 2786. Details of Lightning Arrester. Federal Signal Company.

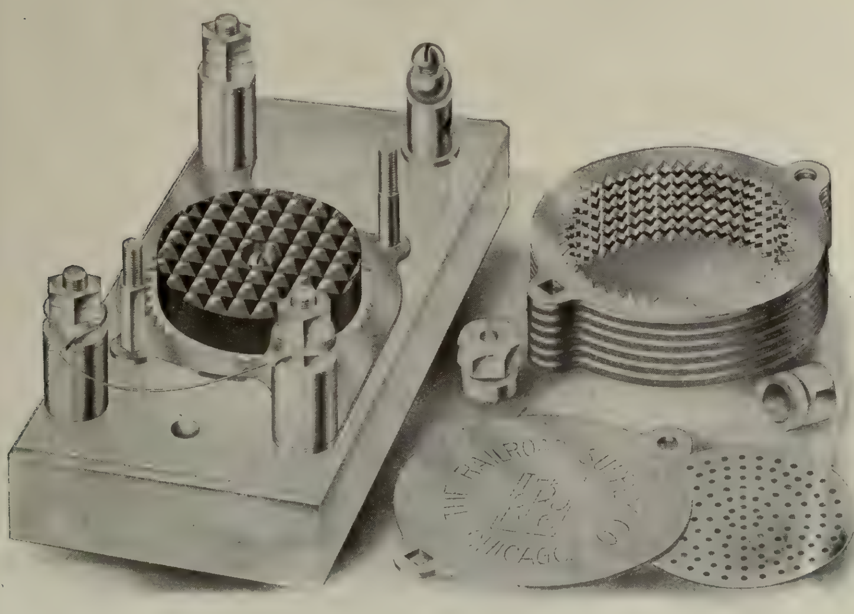


Fig. 2784. Details of Style "F" Lightning Arrester. Railroad Supply Company.

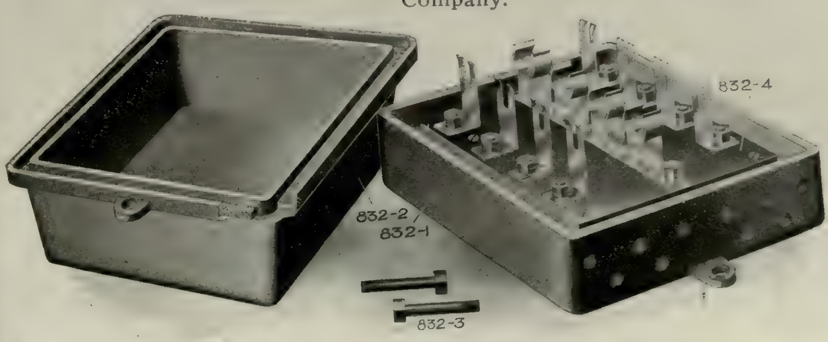


Fig. 2785. Cast Iron Box, with Slate Base for Enclosed Lightning Arresters. Railroad Supply Company.

Fig. 2787. Paragon Ground Cone. Paragon Sellers Company.

Fig. 2788. Method of Installing Paragon Ground Cone. Paragon Sellers Company.

LOCKS

ELECTRIC LOCKS

Figs. 2789-2790 show an electric lock applied to a Saxby & Farmer interlocking machine. D is the rotating locking shaft operated by the lever latch. Arm and link F are connected to segment A mounted on a shaft in the lock. The edge of this segment is notched, according to the locking desired, to engage the dog on B, connected by a bar fastened to the armature of the electromagnet E, and so pivoted that the energizing of the magnet E will raise dog on B out of the notch. An indicator is provided to show when unlocked; a circuit controller operated by the magnet and circuit controller operated by shaft are included in the mechanism for making or breaking circuits controlled by the lever or lock. The bar F may also be attached to the tappet of an interlocking machine which has vertical locking.

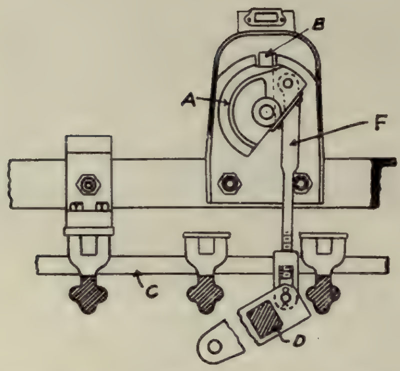


Fig. 2789. Cross Sectional View of Electric Lock. Fig. 2792.

Names of Parts of Electric Lock; Fig. 2792.

1	*Intermediate Bracket*	4	*C. R. Steel Turned Pin*
2	*Connecting Arm*	5	*Angle Iron*
3	*Tap Bolt*	6	*Bolt for* 1 *and* 5

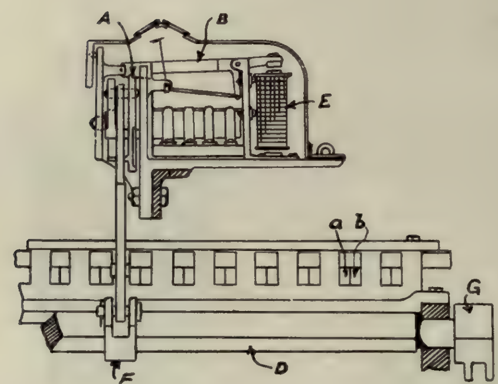


Fig. 2790. Sectional View of Electric Lock, Fig. 2792. Showing Alternative Method of Attaching to Saxby & Farmer Interlocking Machine.

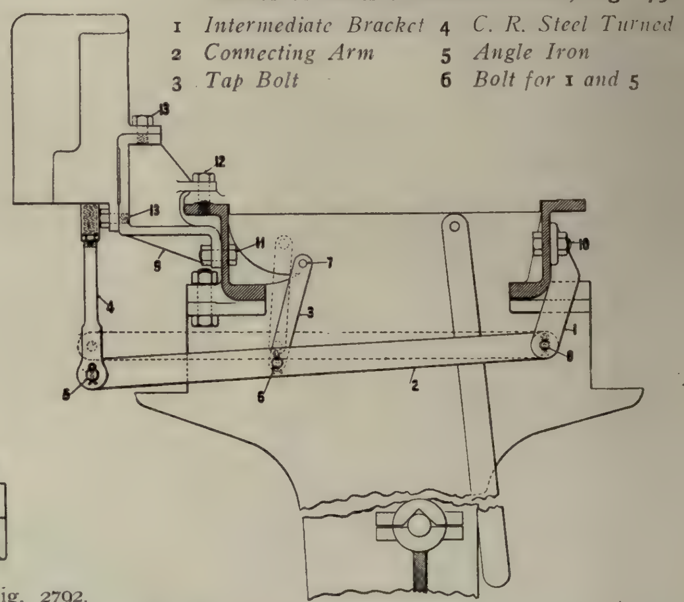


Fig. 2791. Model 7 Electric Lock Applied to a Standard Interlocking Machine.

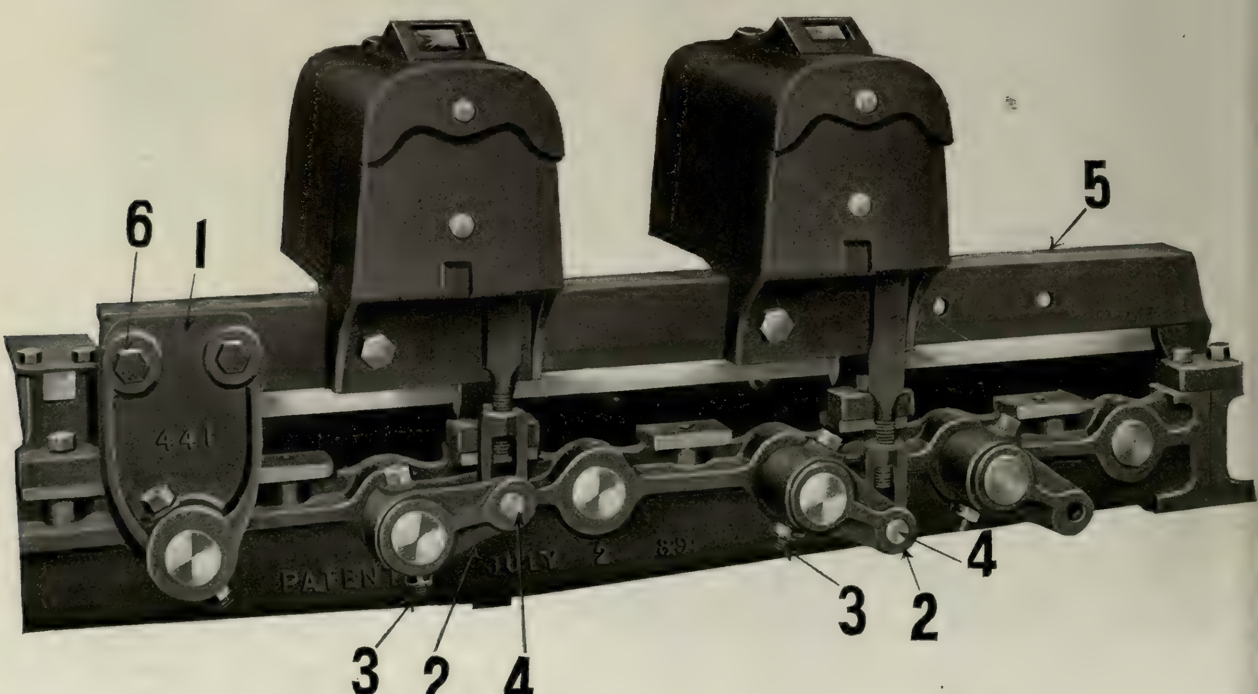


Fig. 2792. Electric Lock Applied to Saxby & Farmer Interlocking Machine.

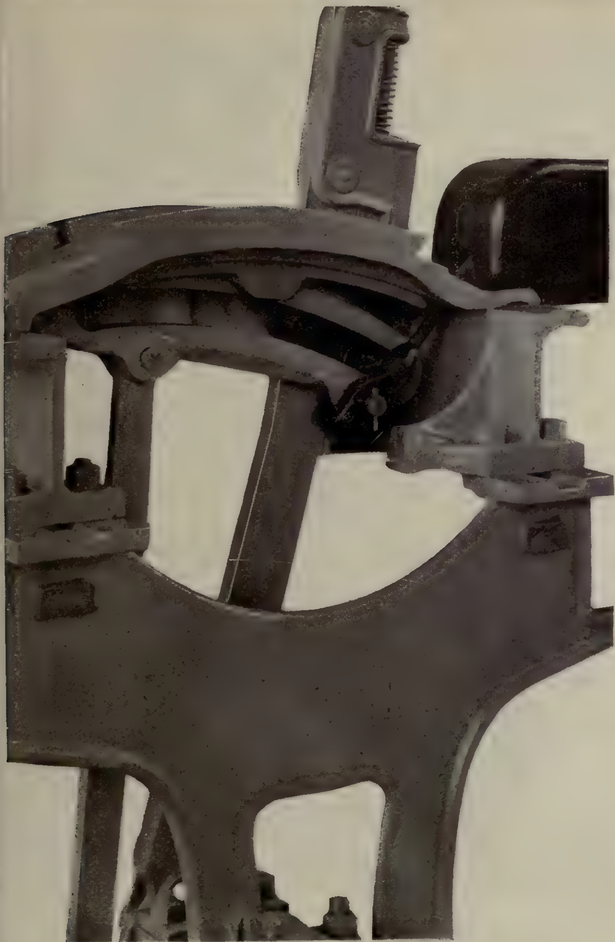


Fig. 2793. Style "B" Electric Lock Applied to Standard Interlocking Machine. General Railway Signal Company.

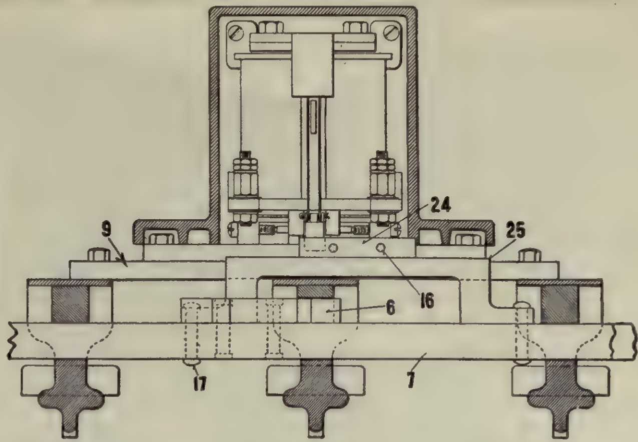


Fig. 2794. Model 2, Electric Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 2 Electric Lock Applied to Saxby & Farmer Interlocking Machine. Fig. 2794.

6 *Dog (Mechanical Locking)*
7 *Locking Bar*
9 *Supporting Plate*
16 *Rivet for* 24
17 *Rivet for* 25
24 *Guard Plate*
25 *Locking Dog*

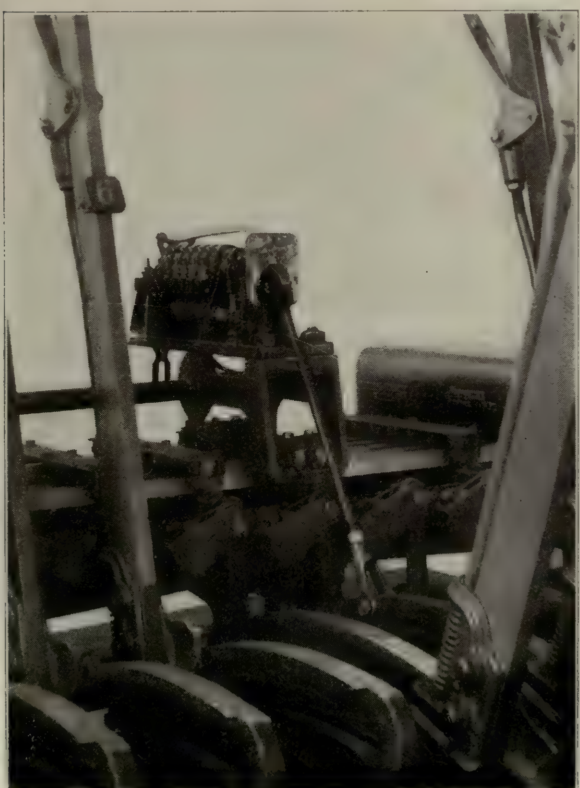
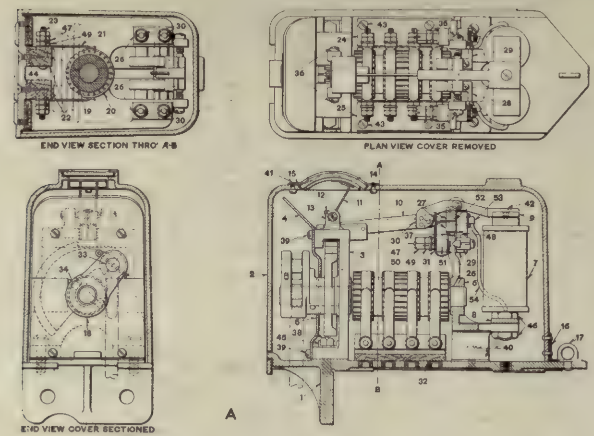
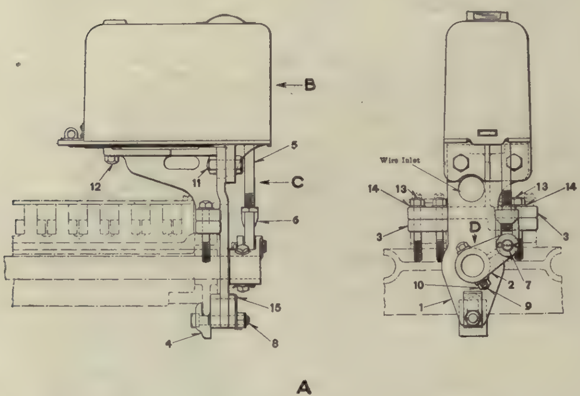


Fig. 2795. Application of Style "B" Electric Lock to Saxby & Farmer Interlocking Machine. General Railway Signal Company.

Fig. 2796. Style "D" Electric Lock Applied to Dwarf Interlocking Machine. General Railway Signal Company.



Figs. 2797-2800. Electric Lock for Mechanical Interlocking Machines. The Union Switch & Signal Company.



Figs. 2801-2802. Union Electric Lock Applied to Improved Saxby & Farmer Interlocking Machine.

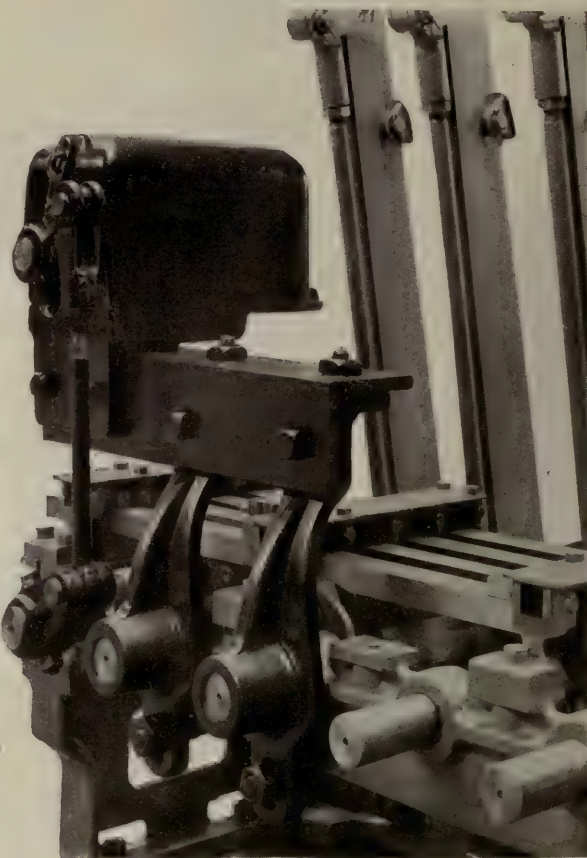


Fig. 2803. Model "F" Electric Lock Applied to Saxby & Farmer Interlocking Machine. General Railway Signal Company.

Names of Parts of Model 7 Electric Lock Applied to No. 2 Johnson Machine; Fig. 2804.

1 *Tappet*
2 *Bar*
3 *Dog*
4 *Filler*
5 *Plate*
6 *Flat Head Machine Screw*
7 *Rivet, Countersunk Head*
8 *Supporting Bracket*
9 *Plunger*
10 *Crank*
11 *Pivot Pin and Cotter*
12 *Turned Pin and Cotter*
13 *Washer*
14 *Tap Bolt*
15, 15a *Machine Bolts*

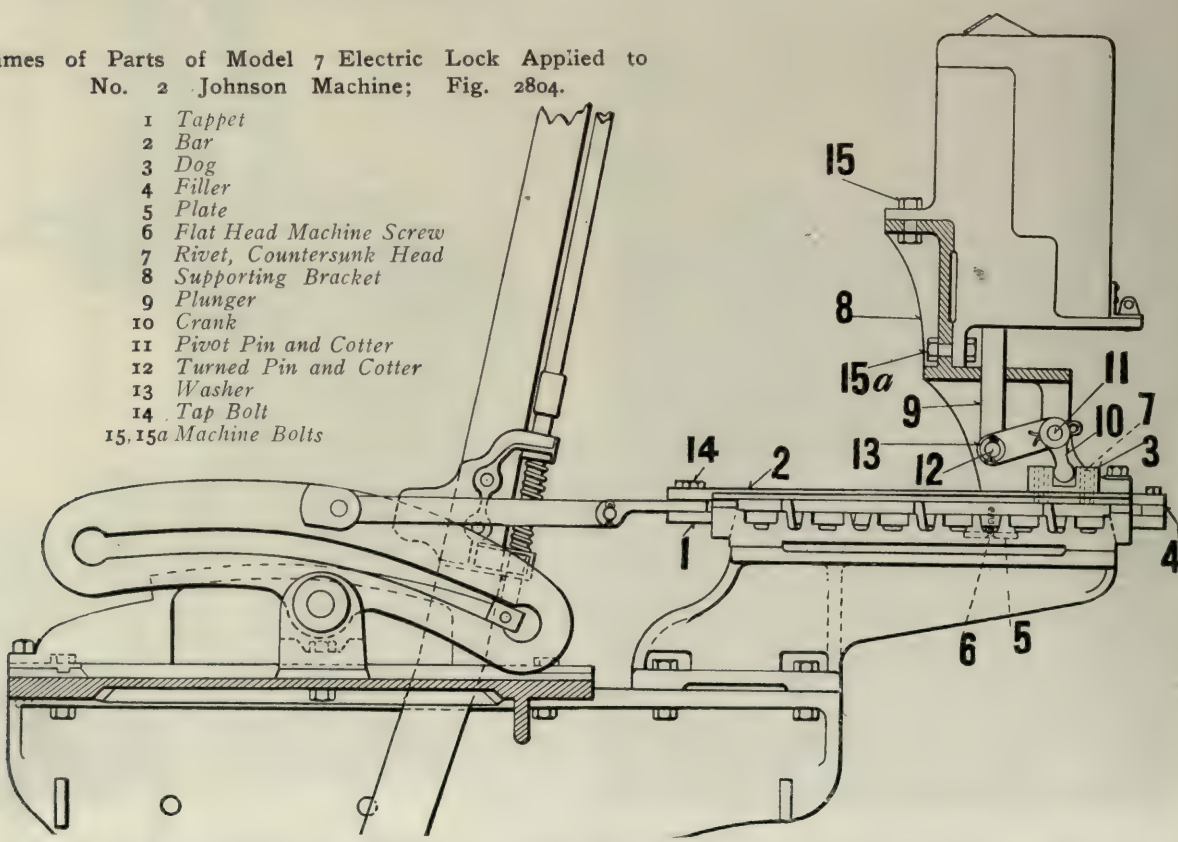
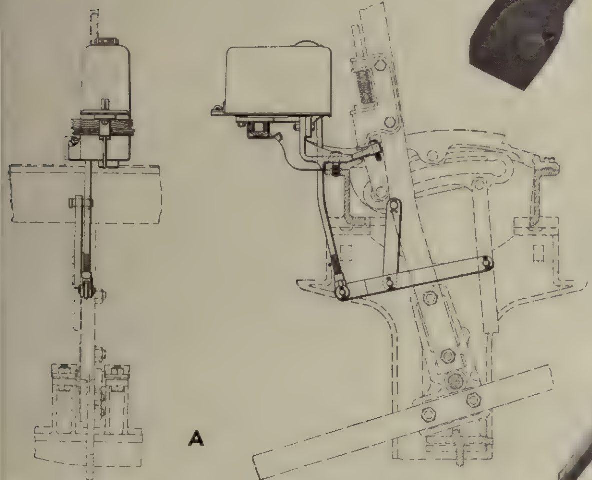


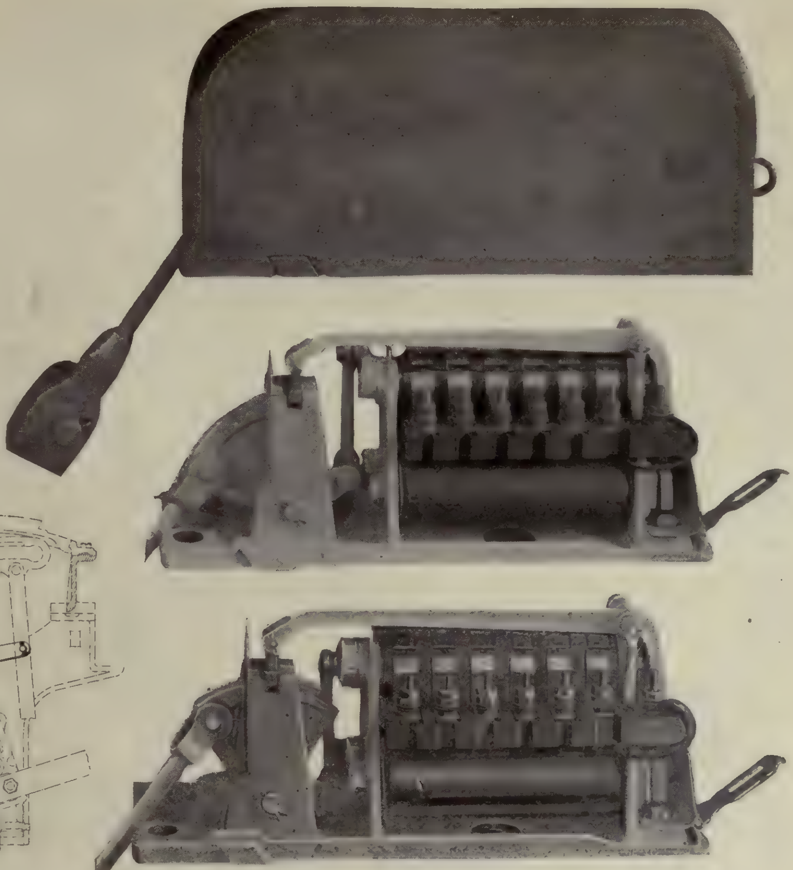
Fig. 2804. Model 7 Electric Lock Applied to Johnson No. 2 Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 1 Electric Lock Applied to Saxby & Farmer Interlocking Machine; Fig. 2810.

3 *Slotted Sheet Iron Plate*
5 *Locking Lever*
7 *Fulcrum Bracket*
13 *C. R. S. Dog*
18 *Flat Head Rivet*
19 *Flat Head Screw, Fastening to 7*
23 *Tap Bolts*



Figs. 2808-2809. Electric Lock Applied to Mechanical Interlocking Machine. Union Switch & Signal Company.



Figs. 2805-2807. Electric Lock Covered; Cover Removed, Segment Engaged by Dog; Dog Raised, Segment Released. General Railway Signal Company.

Names of Parts of Model 1 Electric Lock Applied to a Stevens Interlocking Machine; Figs. 2811-2812.

3 *Slotted Sheet Iron Plate*
4 *Locking Lever*
11 *Right-Hand Supporting Strip*
12 *Left-Hand Supporting Strip*
14 *C. R. S. Dog*
15 *Filler*
18 *Flat Head Rivet for Fastening 19 to Tappet*
19 *C. R. S. Dog*
20 *Tap Bolts for 11 and 12*
21 *Flat Head Rivet for Fastening 14 to Tappet*
23 *Tap Bolt for Fastening Frame to 11 and 12*
39 *Flat Head Machine Screw for Fastening 11 and 12 to Machine.*

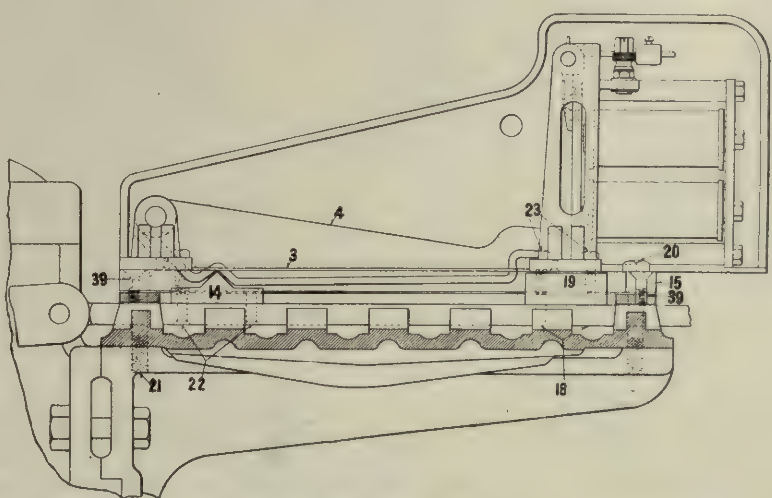
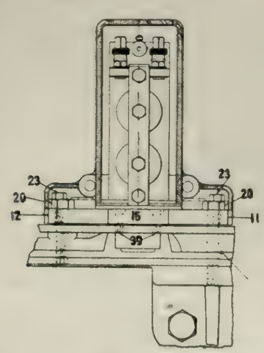
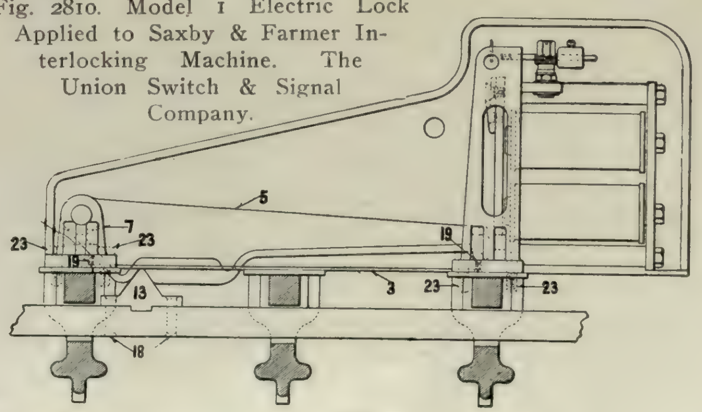


Fig. 2810. Model 1 Electric Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.





Figs. 2811-2812. Model 1 Electric Lock Applied to Stevens Interlocking Machine.

ELECTRIC SWITCH LOCKS.

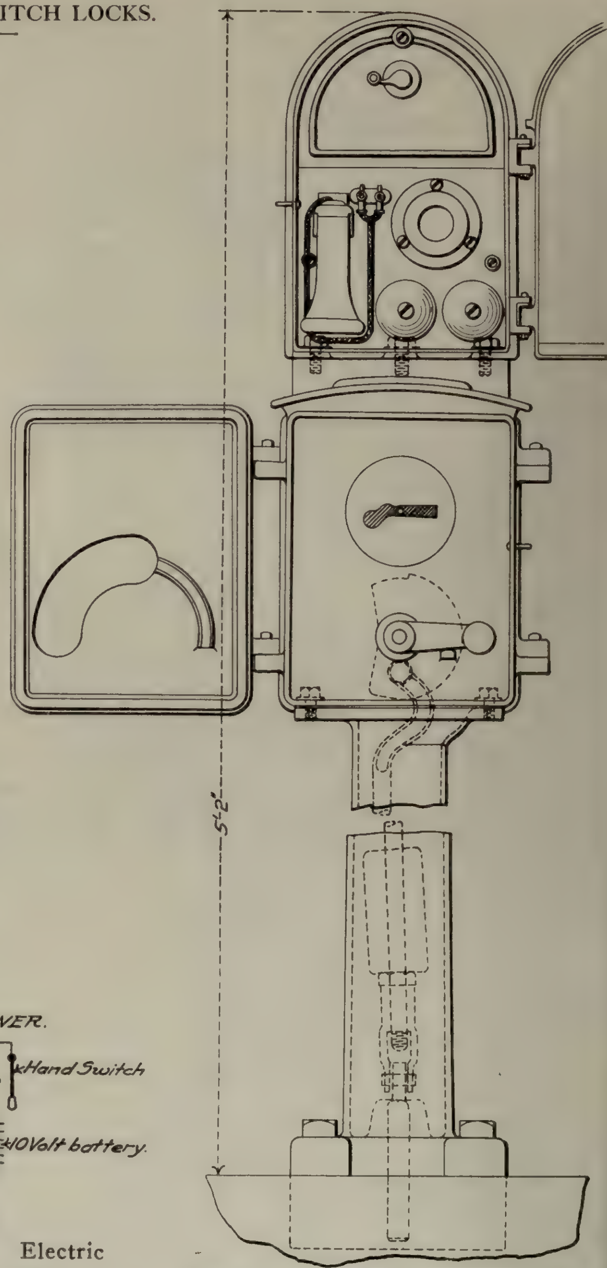


Fig. 2815. Switch Lock with Telephone. General Railway Signal Company.

G. R. S. ELECTRIC SWITCH LOCK.

In Figs. 2816-2817 are shown a switch lock made by the General Railway Signal Company applied to a switch and a control circuit for operating it. The switch lock consists primarily of a weighted vertical plunger, designed to pass through a hole in the switch lock rod, actuated by a hand lever. On the same shaft with the lever is a notched quadrant so arranged that a dog attached to the armature of an electromagnet will drop into the notch and hold the apparatus immovable when the magnet is de-energized and the plunger down. A small semaphore indicator is provided to give visual indication of the condition of the magnet. The whole is mounted in an iron box set on an iron post.

Fig. 2815 illustrates a further development of the switch lock shown in Figs. 2816-2817. Here a telephone is added mounted in a box above the switch lock so that trainmen may communicate with the operator, who controls the lock and who has a telephone in his office connected to the one at the switch.

The electric switch lock shown in Fig. 2818-2819 consists of an electro-magnet having two front and two back contacts. When the magnet is energized, a locking dog is lifted from a notch in the plunger, allowing the switch to be thrown. The movement of the plunger operates a three-way circuit controller. When the magnet is de-energized, the dog falls by gravity, and locks the switch in the desired position by engaging with the notch of the plunger.

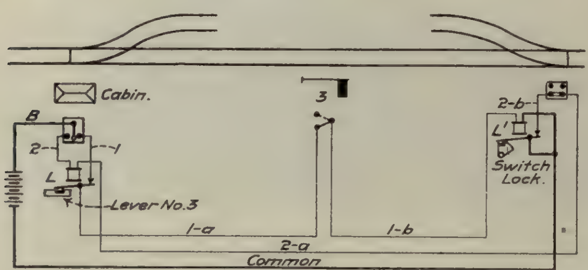


Fig. 2813. Circuits for Outlying Electric Switch Lock at Block Station. Erie Railroad.

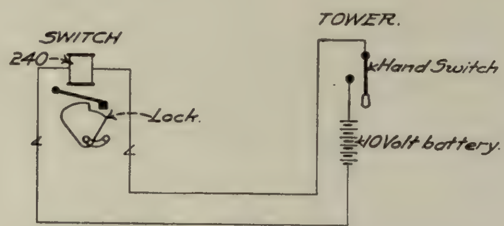
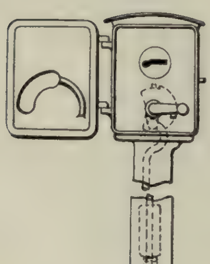
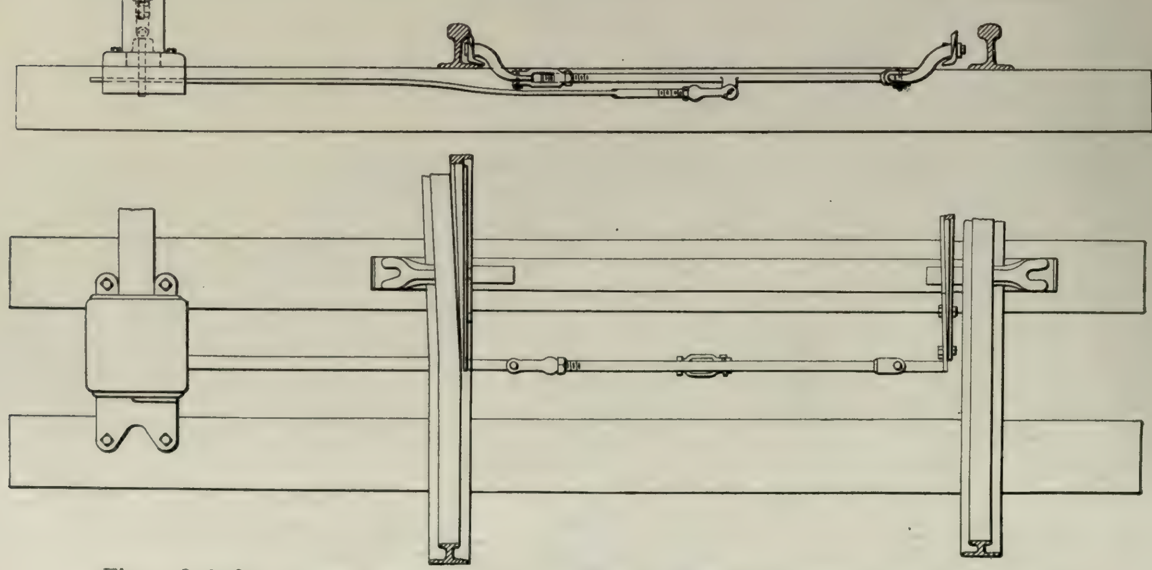
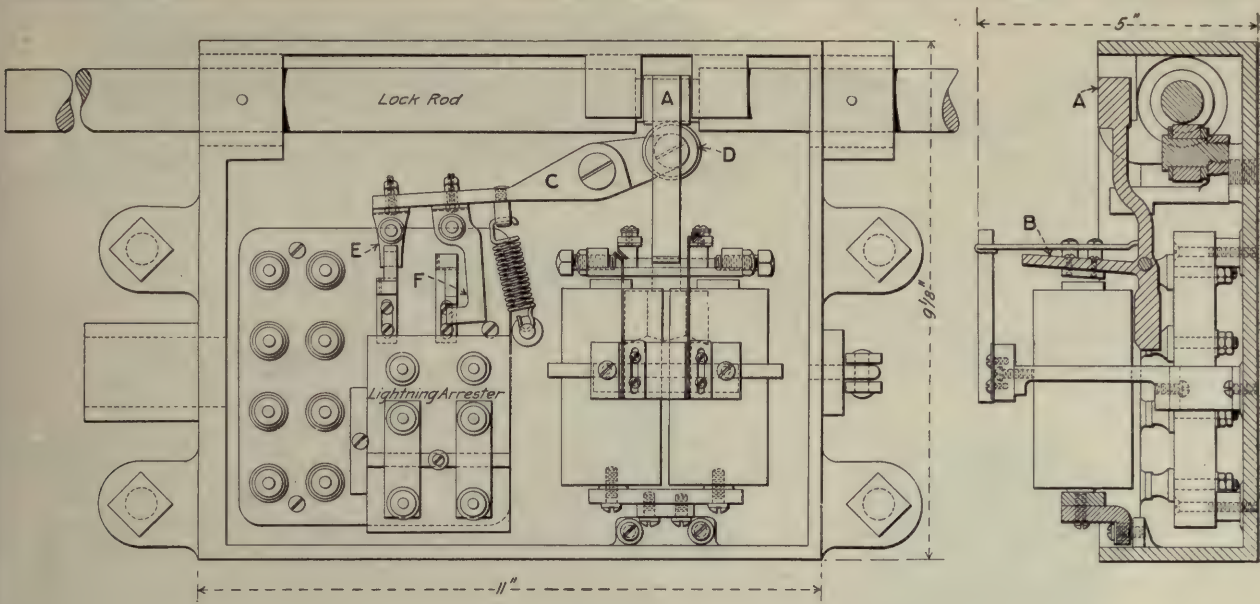


Fig. 2814. Circuit for Electric Switch Lock. General Railway Company.





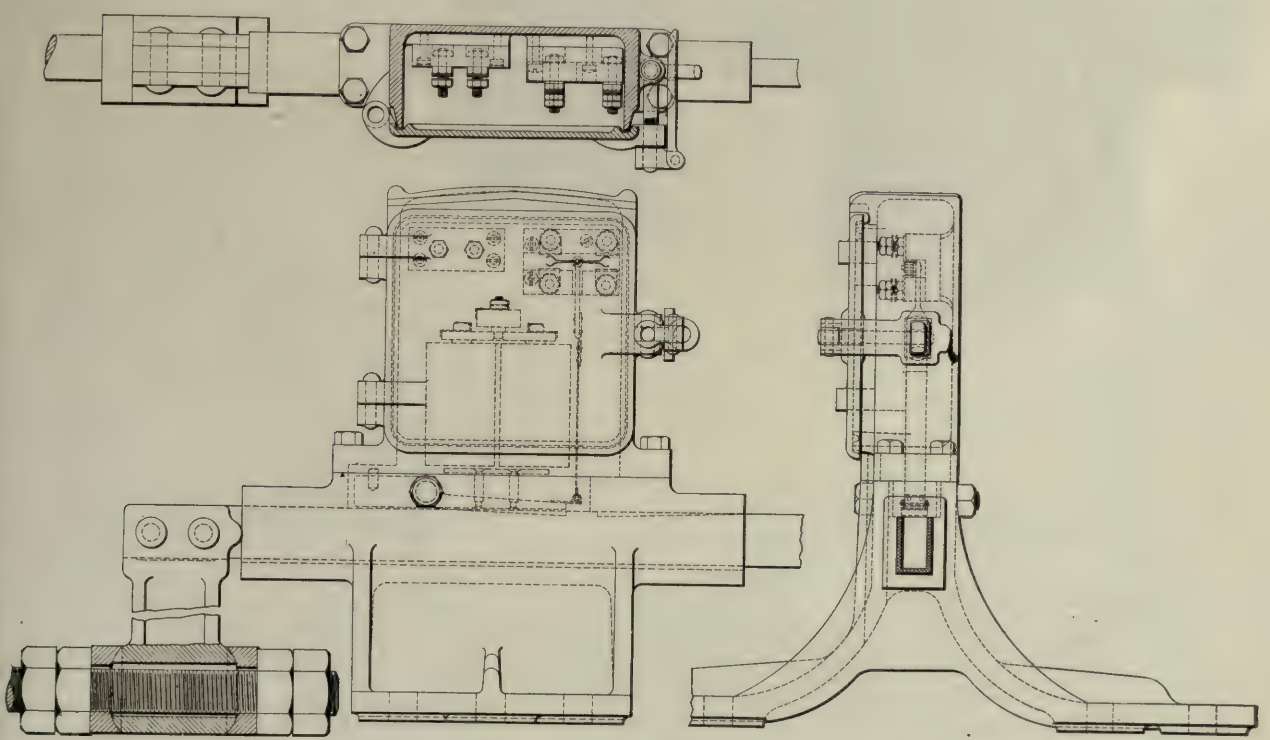
Figs. 2816-2817. Electric Switch Lock in Place. General Railway Signal Company.



Figs. 2818-2819. Electric Switch Lock.

Names of Parts, Electric Switch Lock; Figs. 2818-2819.

A *Armature Lever and Latch Dog*
B *Armature*
C *Circuit Controller Arm*
D *Roller*
E *Front Contact Arm*
F *Back Contact Arm*



Figs. 2820-2822. Electric Switch Lock. American Railway Signal Company.

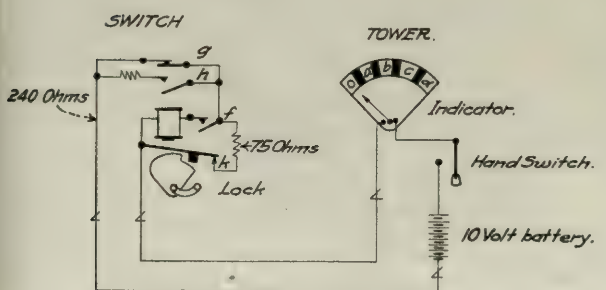


Fig. 2823. Circuits for Electric Switch Lock with Repeater. General Railway Signal Company.

NOTE.

Indicator Needle at a = Switch unlocked.
" " " b = Lock door open.
" " " c = Switch locked in normal position.
" " " d = Something out of order
" " " o = Something out of order.

f = Contact, operated by lock door, made when door is open.
g = Contact, operated by lock handle, broken when switch is unlocked.
h = Contact, operated by lock handle, made when switch is unlocked.
k = Back-contact on lock armature.

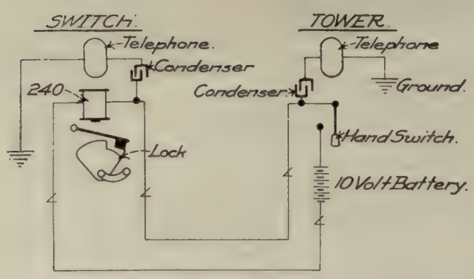


Fig. 2824. Circuits for Electric Switch Lock with Telephone. (See Fig. 2815.)

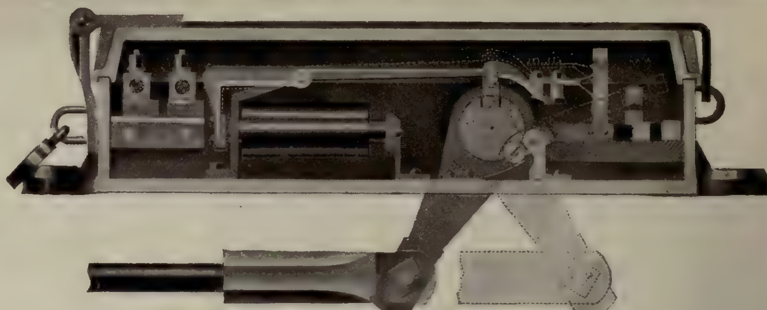


Fig. 2825.

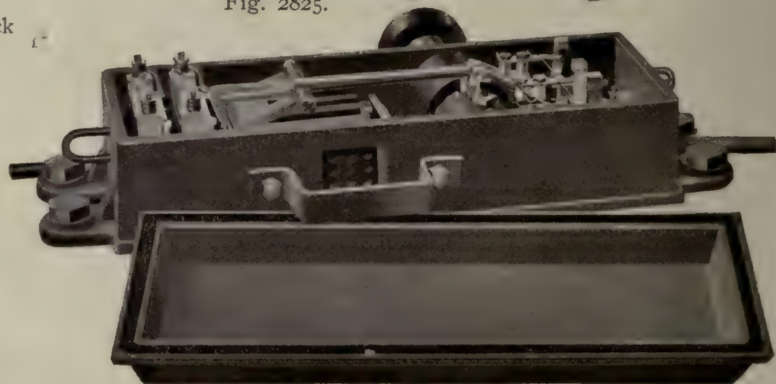


Fig. 2826.

Figs. 2825-2826. Electric Switch Locks. Railroad Supply Company.

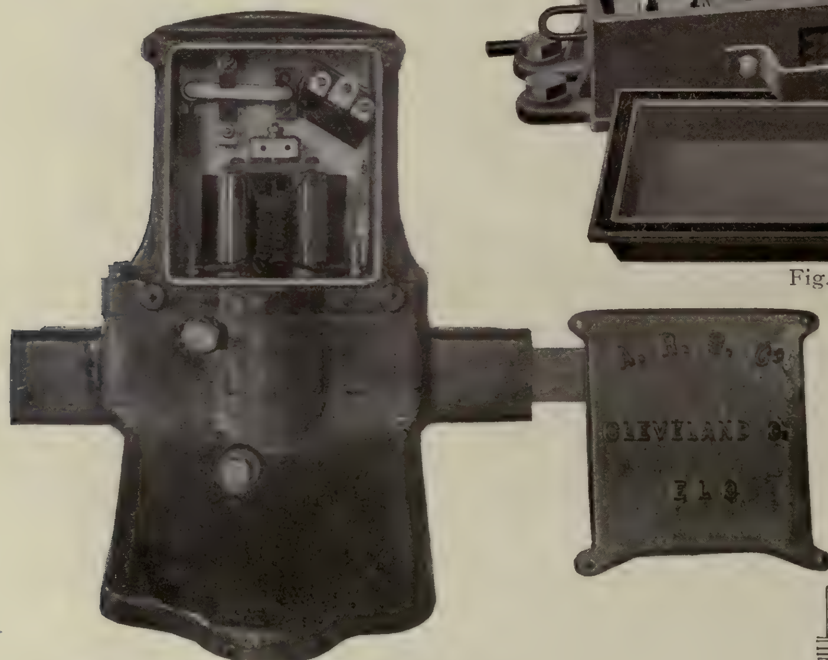


Fig. 2827. Electric Switch Lock. American Railway Signal Company.

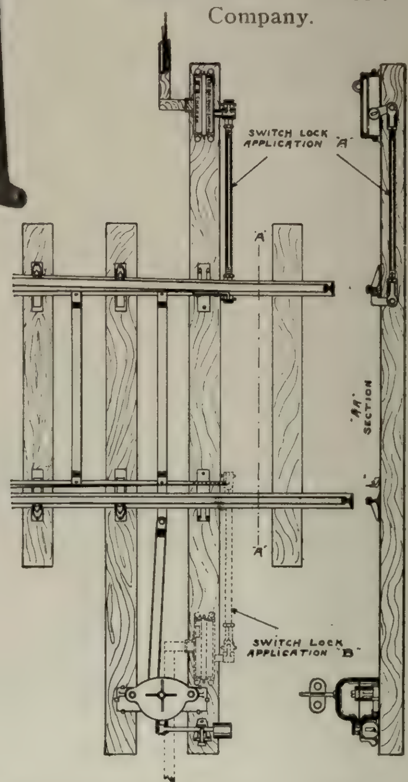
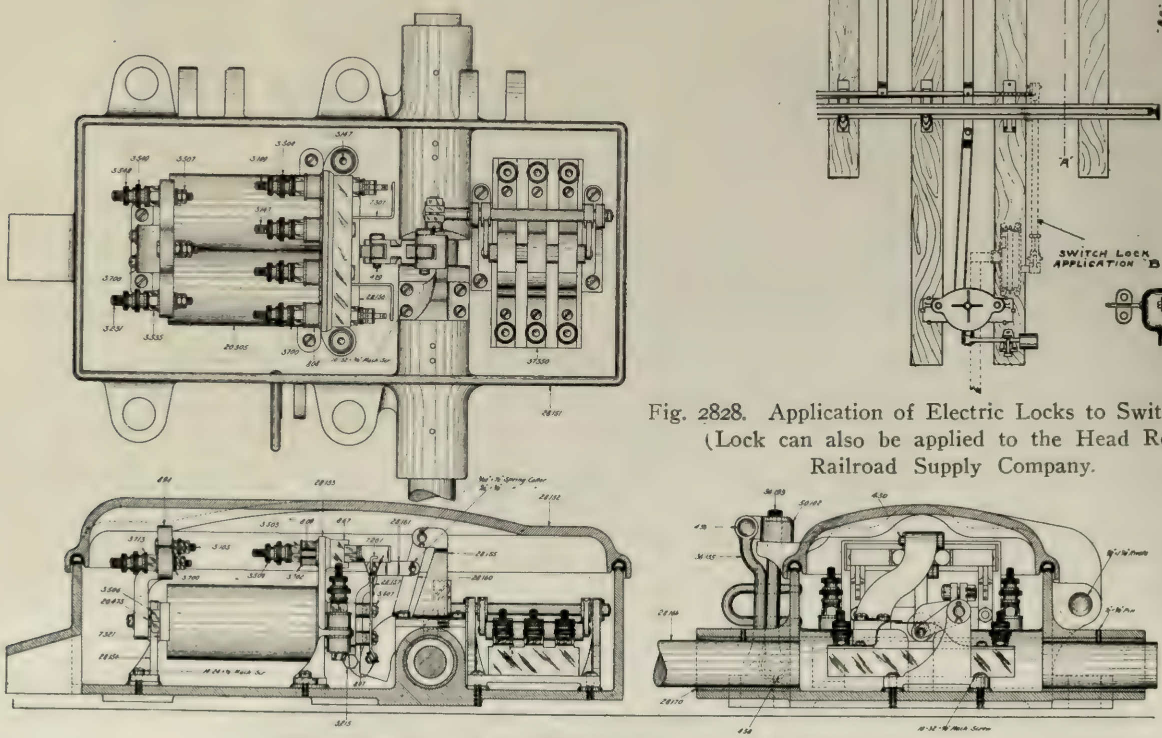


Fig. 2828. Application of Electric Locks to Switch Point. (Lock can also be applied to the Head Rod.) Railroad Supply Company.



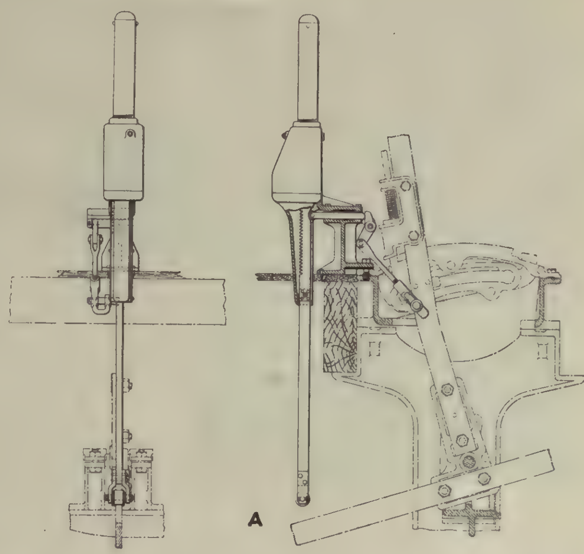
Figs. 2829-2830. Style "F" Switch Lock. Hall Signal Company.

MECHANICAL TIME LOCKS AND TIME RELEASES.

MECHANICAL TIME LOCKS.

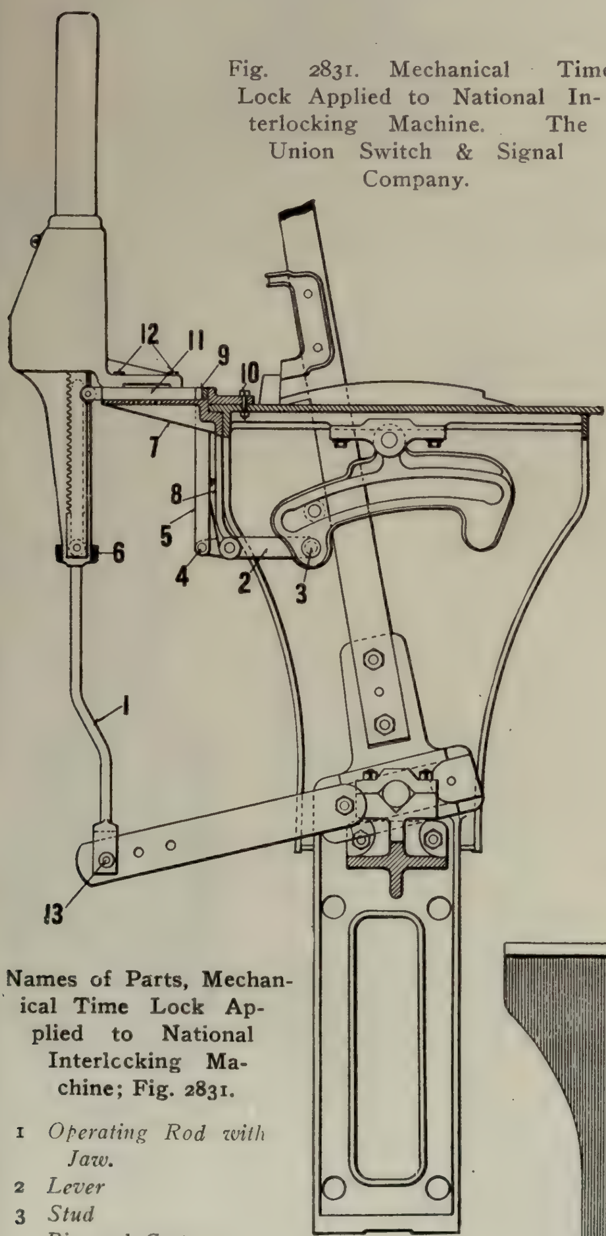
Mechanical time locks are employed with interlocking machines to introduce a time element between placing signal or other levers normal, and any change in the route for which the signal or other function was reversed. They are used instead of electrical track circuit approach locking and are operative for every movement of the signal or other lever.

Fig. 2840 shows the mechanical time lock made by the Union Switch & Signal Company. The contact of the lever locking is secured by engagement with an extra piece of cross locking driven by a bar in the time lock vertically moved as the lever is reversed. A rack on this bar engages a gear wheel connected to a ratchet and escapement in such a manner as to permit a quick movement of the lever to the reversed position to



Figs. 2832-2833. Mechanical Time Lock Applied to Standard Interlocking Machine. The Union Switch & Signal Company.

Fig. 2831. Mechanical Time Lock Applied to National Interlocking Machine. The Union Switch & Signal Company.



Names of Parts, Mechanical Time Lock Applied to National Interlocking Machine; Fig. 2831.

1 *Operating Rod with Jaw.*
2 *Lever*
3 *Stud*
4 *Pin and Cotter*
5 *Locking Bar*
6 *Guide*
7 *Bracket*
8 *Bracket for Supporting* 5
9 *Cross Locking*
10 *Bolt*
11 *Cross Locking Dog*
12 *Cap Screw*
13 *Pin and Cotter*

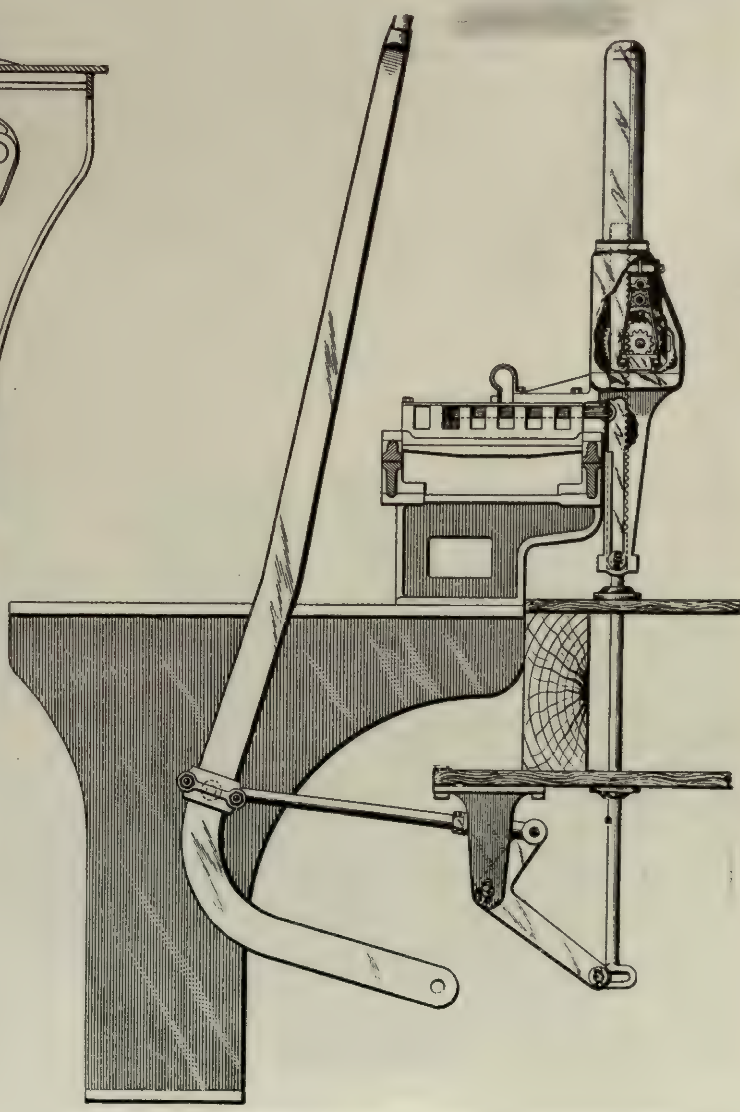


Fig. 2834. Mechanical Time Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

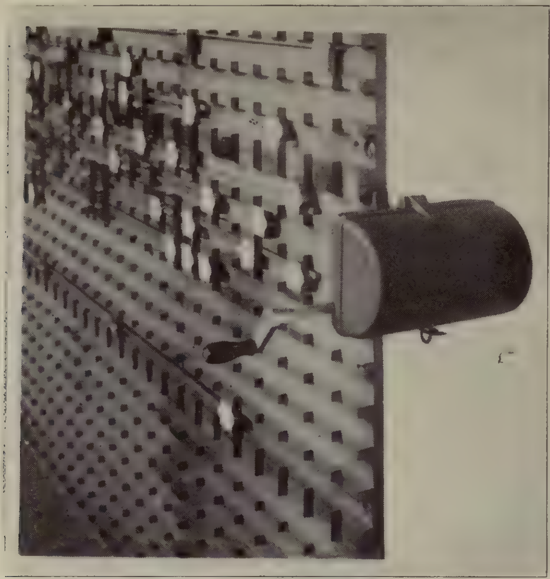
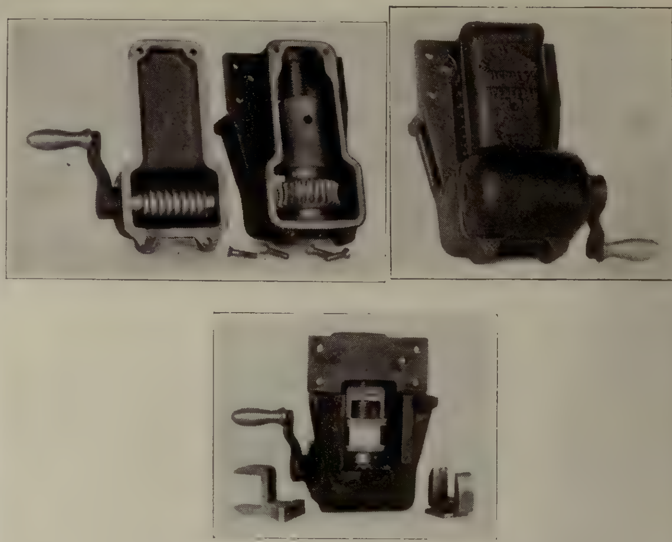


Fig. 2835. Electro Mechanical Hand Screw Release Applied to Electric Interlocking Machine. General Railway Signal Company.



Figs. 2836-2838. Universal Hand Screw Release for Mechanical Interlocking Machines. General Railway Signal Company.

lock the switch levers but requiring a slow movement consuming one minute or more to place the lever normal, lower the bar and release the switch locking.

TIME RELEASES.

Slow hand or time releases are employed in connection with electric locks on interlocking machines to release mechanically the electric locks after an operation. They require from 20 seconds to two minutes to operate. The operation may also mechanically lock certain levers so as to insure the return of the device to the normal position to unlock such levers. Hand releases are usually employed at an interlocking plant having approach locking, to release such locking in case of emergency when it has become effective because of the approach of a train and a change of route is necessary.

The hand screw release, Figs. 2843-2845, is made by the General Railway Signal Company. Circuits may be controlled by this device. When the apparatus is normal the crosshead is at the extreme left hand end at screw L. When in this position insulated pin H has forced the left hand center con-

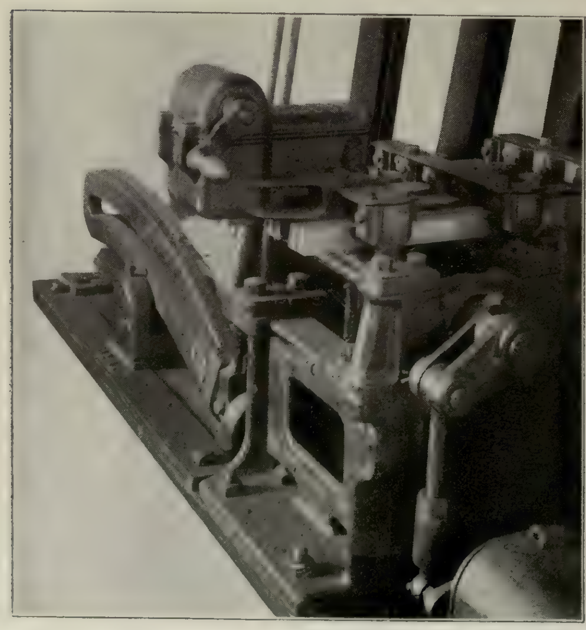
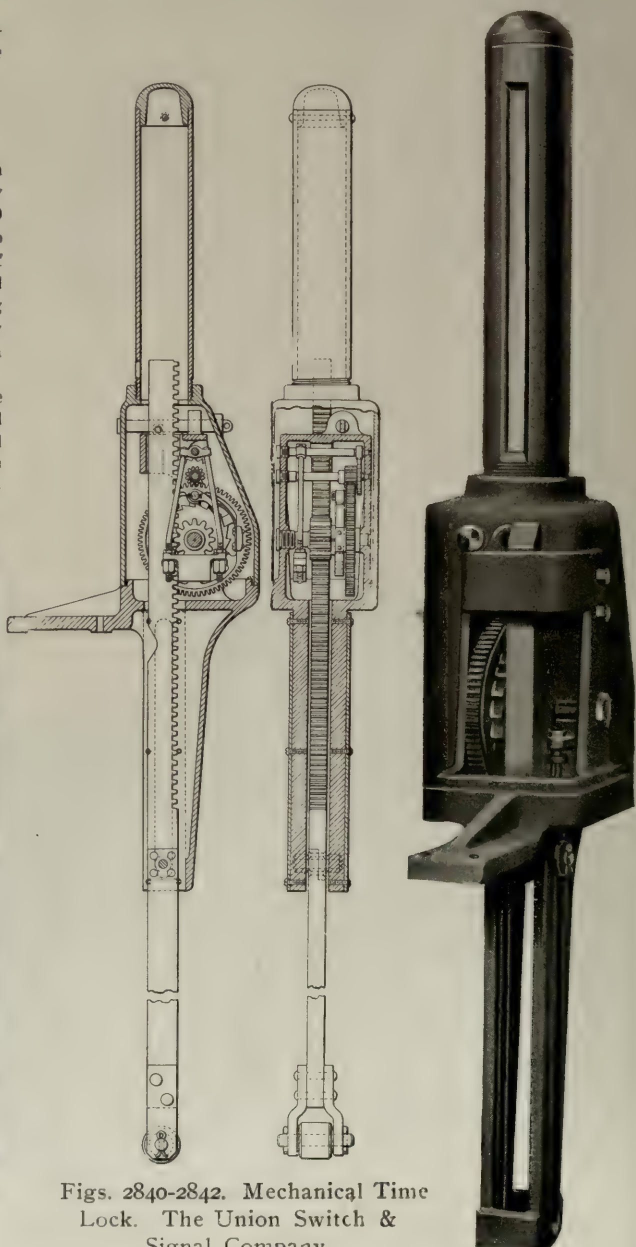


Fig. 2839. Application of Universal Hand Screw Release to Saxby & Farmer Interlocking Machine. General Railway Signal Company.



Figs. 2840-2842. Mechanical Time Lock. The Union Switch & Signal Company.

tact O against the side contact spring N and the head of O will be held by the notch in retaining spring P. It cannot slip out of this notch and break the circuit until H strikes against the end of P, thereby raising it. When the apparatus is in the full reverse position the right hand set of contact springs is operated in the same manner by H. Thus, it is necessary to operate the device through its full stroke forward and back in order to accomplish a release and restore the circuits. As the center contact springs O snap from their extreme positions a quick break is accomplished avoiding an arc.

Figs. 2846-2847 show the application of a mechanical screw release to an interlocking machine with vertical locking. The release actuates an extra tappet carrying a special dog which drives a piece of cross locking. This piece of cross locking is provided with a wedge which enters the lock box and raises the dog in the lock from engagement with the locking of the machine. The piece of cross locking will butt against and hold all the locking having to do with the tappet on which the lock acts when the screw release is reversed, thereby holding the route locked until the release has been returned to its normal position.

In Fig. 2855 is shown an application of an electrical time circuit breaker (Figs. 2849-2852) used to introduce a time element in releasing the route locking of an interlocking plant. The time circuit breaker is an electrical device which will make or break one or more circuits a predetermined number of minutes after it has been put in action. Reversal of any one of the signal levers opens circuit breaker L and de-energizes relay B. This opens the circuit of lock C which passes from battery E through contact of B, wire J, contact of A, to terminal O, through contact of time circuit breaker, terminal M, floor push D, lock C to battery. Relay B is a stick relay and

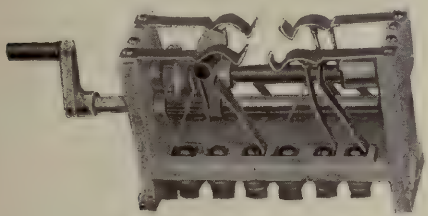
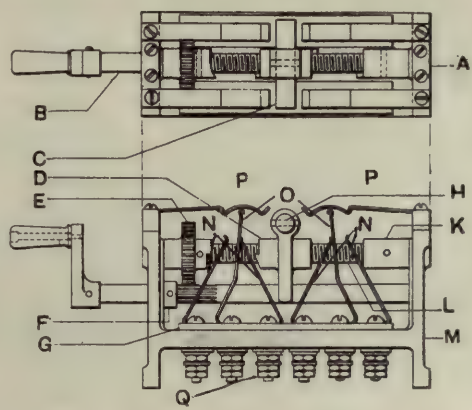


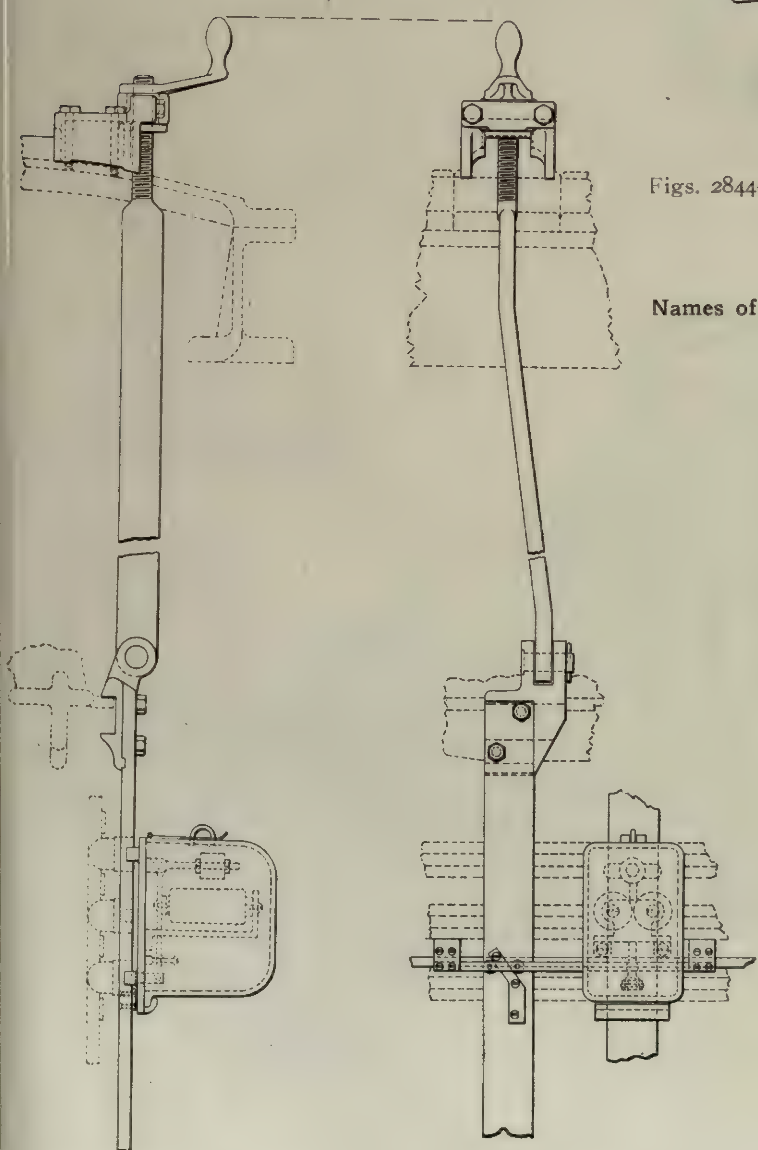
Fig. 2843. Electrical Screw Hand Release. General Railway Signal Company.



Figs. 2844-2845. Electrical Screw Hand Release. General Railway Signal Company.

Names of Parts, Screw Hand Release; Figs. 2844-2845.

- **A** *Insulating Block*
- **B** *Pinion Shaft with Handle*
- **C** *Crosshead Insulator*
- **D** *Crosshead*
- **E** *Gear Wheel*
- **F** *Collar*
- **G** *Contact Post Insulator*
- **H** *Pin*
- **K** *Back Sleeve*
- **L** *Operating Screw*
- **M** *Frame*
- **N** *Side Contact Spring*
- **O** *Center Contact Spring*
- **P** *Retaining Spring*
- **Q** *Binding Posts*



Figs. 2846-2847. Mechanical Screw Hand Release Applied to An Interlocking Machine with Vertical Locking. General Railway Signal Company.

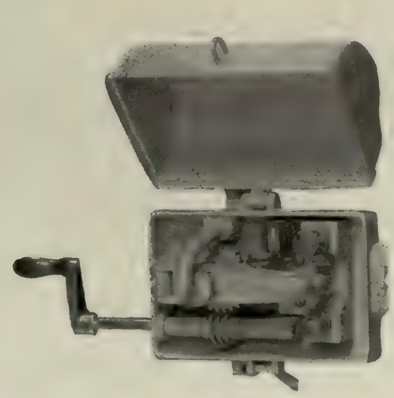


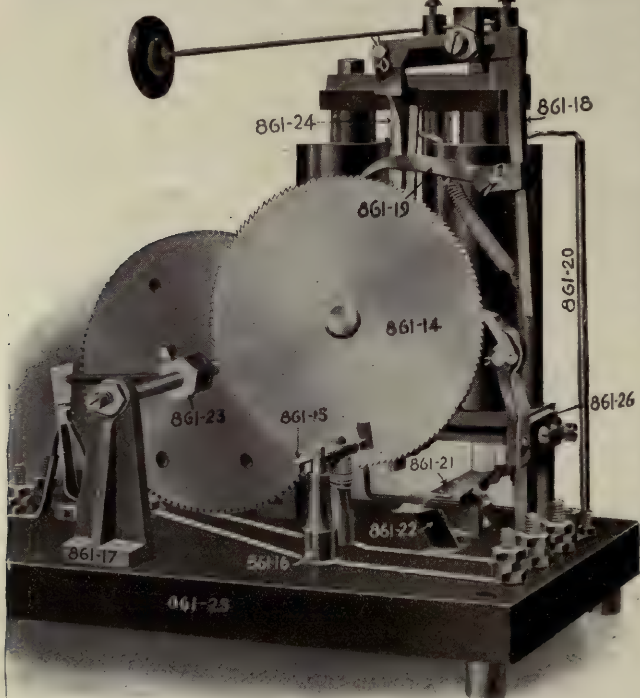
Fig. 2848. Electro-Mechanical Hand Screw Release. General Railway Signal Company

cannot again pick up until relay A is de-energized, owing to the presence of a train on the track circuit with all signal levers normal or until the time release has acted. When relay A is de-energized it restores B through a back point but keeps the circuit for lock C open. Relay A is also a stick relay and cannot pick up until B is energized. If the wrong route has been lined up and it is necesary to restore the functions to normal without being released by a train, the signalman presses the strap-key which puts the time circuit breaker in operation. After the proper interval of time contacts N and P are brought together and relay B is energized thereby, but at the same time contacts M and O are opened, thereby keeping lock C de-energized until the time circuit breaker has ceased to act.

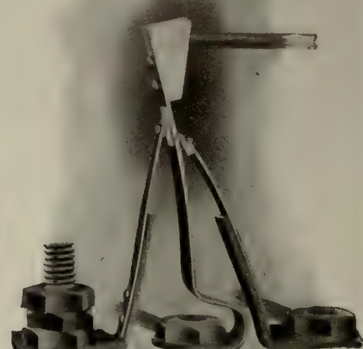
With the electric locks on the switch levers the operation of the emergency release, Figs. 2853 and 2857, made by the Union Switch & Signal Company, is as follows:

The signal lever being normal, the handle is turned to lock the signal lever normal mechanically and release the electric lock on the switch lever mechanically. The switch lever can now be reversed. Reversal of the direction of rotation of the handle restores the device to its normal position, thus releasing the signal lever from this special mechanical locking. If the electric locks are on the signal levers the switch levers are locked during an operation. The time required for an operation depends upon the apparatus and adjustment provided. The slow speed apparatus consists of gearing, in the circular case, turned by the wheel and handle to drive a special locking bar as shown in Fig. 2854, which represents the electric lock and the special releasing arrangement underneath. The locking bar is connected by a lug 1, and link 2, to the slotted bar 4, engaging with the rod 5, in such a manner as to operate mechanically the armature of the electric lock, raise the locking dog and release the lock. Fig. 2854 shows the lock released and the locking bar in its full reversed position. This locking bar in any other than its normal position mechanically locks the signal lever normal through the cross locking.

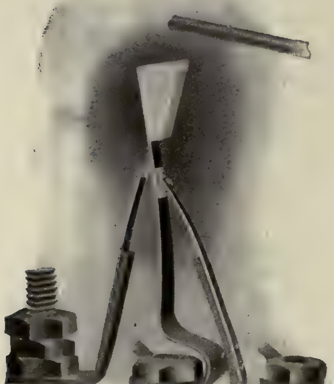
The devices in Fig. 2853, made by the Union Switch & Signal Company, perform the same function electrically as the releases already described, by closing normally open circuit controllers, in the rectangular boxes, shown with covers removed, thereby affecting the lock circuit. To insure its return to the normal position other circuit controllers, normally closed, affecting the control or locking of the signals are opened to prevent the clearing of the signals during the operation of the release. This may also be arranged to lock conflicting levers mechanically. The electric lock shown in this illustration is not connected, except electrically, with the hand releases. In this arrangement the hand wheel, through gearing, slowly moves the flat bar leading into the circuit controller box. To this bar is attached a contact plate engaging springs in such a manner as to open and close contacts as described. The circuit controller box is the same as that employed in the electro-pneumatic system for indication boxes at switches.



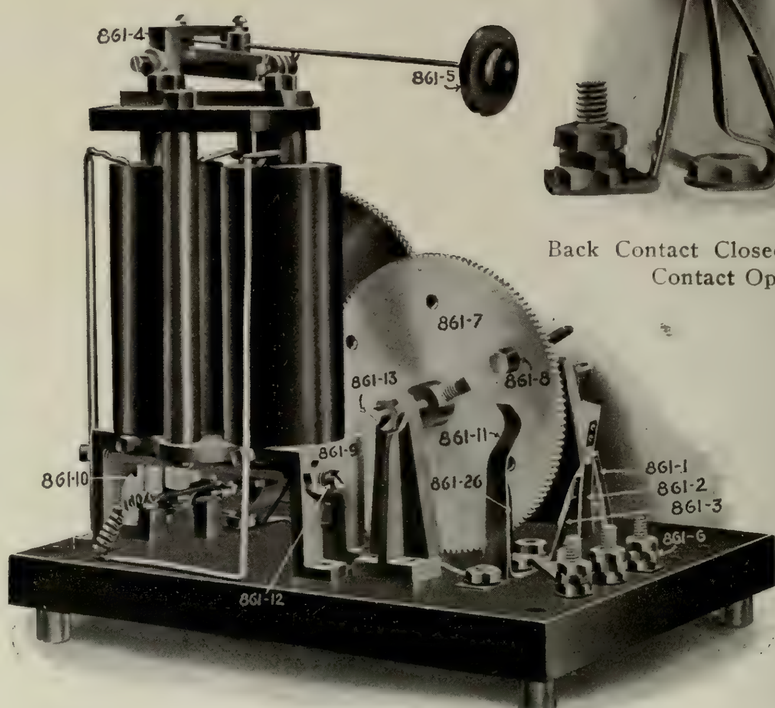
Front View.



Back Contact Closed, Front Contact Open.



Front Contact Closed, Back Contact Open.



Rear View.

Figs. 2849-2852. Electrical Time Circuit Breaker and Contacts. Railroad Supply Company.

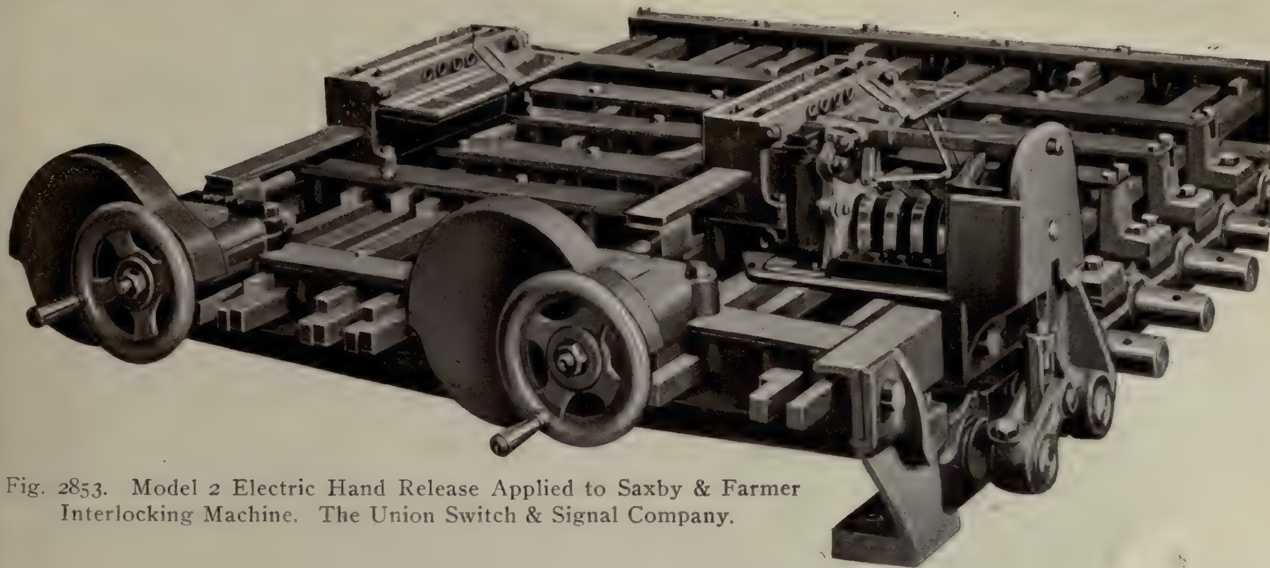


Fig. 2853. Model 2 Electric Hand Release Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

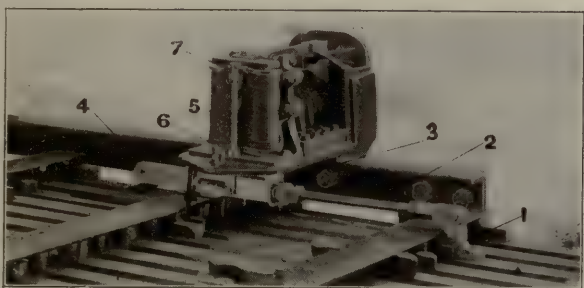


Fig. 2854. Releasing Attachment for Model 2 Electric Lock Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts, Releasing Attachment for Model 2 Electric Lock Applied to a Saxby & Farmer Interlocking Machine; Fig. 2854.

1	*Lug*	5	*Brass Operating Rod*
2	*Adjustable Link*	6	*Brass Bushing*
3	*Motion Plate Guide*	7	*Spring*
4	*Motion Plate*		

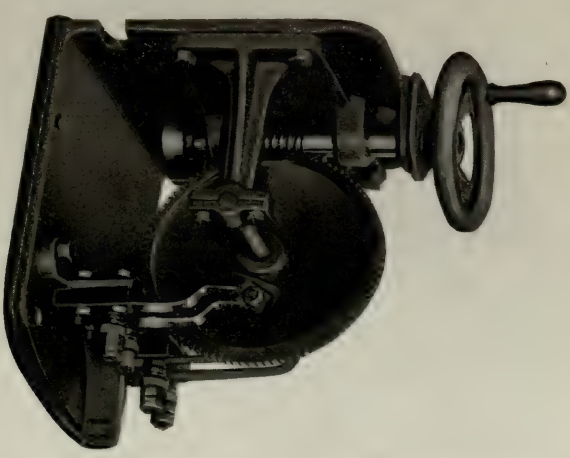


Fig. 2856. Wall Type Hand Screw Release Circuit Controller with Cover Removed. The Union Switch & Signal Company.

Names of Parts, Route Locking Circuits with Electrical Time Circuit Breaker; Fig. 2855.

A *Track Relay*
B *Control Relay*
C *Electric Lock*
D *Floor Push*
E *Main Battery*
F *Track Battery*
G *Operating Terminal on Time Circuit Breaker*
J *Wire*
K *Operating Terminal in Time Circuit Breaker*
L *Circuit Breaker Operated by Signal Levers*
M *Contact*
O *Contact Arm*
R *Track Relay Lead*
S *Track Relay Lead*
T *Wire*

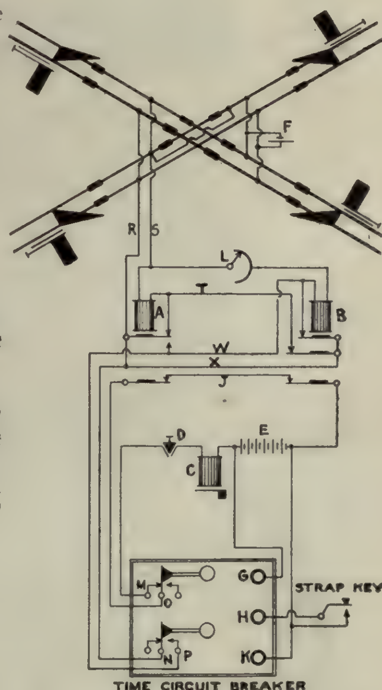


Fig. 2855. Electrical Time Circuit Breaker Used as Time Release for Route Locking Circuits. Railroad Supply Company.

Figs. 2856 shows another type of instrument made by the Union Switch & Signal Company, designed to accomplish the same result as those above described by a semi-electrical method. It is used principally with power interlockings where it may be placed at any desired point in the tower. A gear wheel is driven by a worm gear on a shaft to which is connected the hand wheel. The movement of the gear wheel can be arranged to open or close one or more contacts as desired to affect the control of signals and locks and require the return to its normal position. Provision is made for controlling the high voltage currents employed in electric interlocking by having contacts of a slightly different construction. A brake is also provided so as to prevent false movements from affecting the contacts. An indicator can be furnished to show the position of the apparatus, while the cams driven by the gear wheel control the contacts in such a manner as to provide for always turning the handle in the same direction for restoring as for setting, giving, if desired, a long time interval for releasing the locks and a very short interval for returning to the normal position.

CLOCKWORK TIME RELEASE.

The clockwork time release shown in Figs. 2858-2859 is designed for the same purposes as the hand release, but unlike the latter does not require the continued manipulation of the instrument by the operator for the entire time interval. This leaves him free to perform his other duties after merely turning the knob to the right against the stop and permitting it to return slowly to the time desired by means of the clockwork mechanism.

The maximum time interval which can be secured on this instrument is four minutes, and the design is such that the interval can be varied to any time between that amount and zero by the adjustment of stops in the instrument.

The instrument is made in two forms; one in which the pointer stands normally at whatever time interval it is desired to secure, and the other in which the knob and pointer are latched at zero. In the former type the operator merely turns the knob to zero and releases it, permitting the clockwork to restore it to the time desired. In the second type the operator after turning the knob to zero gives a small movement to the left to release the latch, when it will automatically return to the time desired. In neither type, however, is the operator able, by turning the knob to the left, to vary the time required to effect the release.

It will be noticed from the foregoing that the second type of release equipped with a retaining pawl or latch can be used for the same purposes as the type without such an attachment, since the operator can, after turning his knob as far as it will go to the right, give it the slight left hand turn, which is necessary to release the retaining pawl and allow it to return, —in practically one operation.

In addition to hand operation, this release can be operated by the lever of any type of interlocking machine by substituting an attachment in place of the knob and omitting the retaining latch entirely.

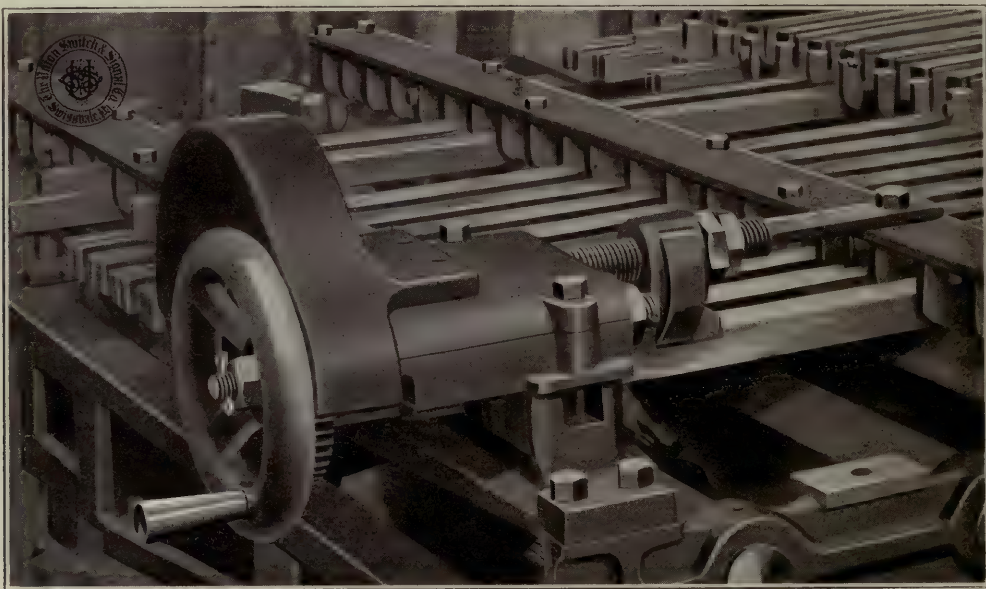
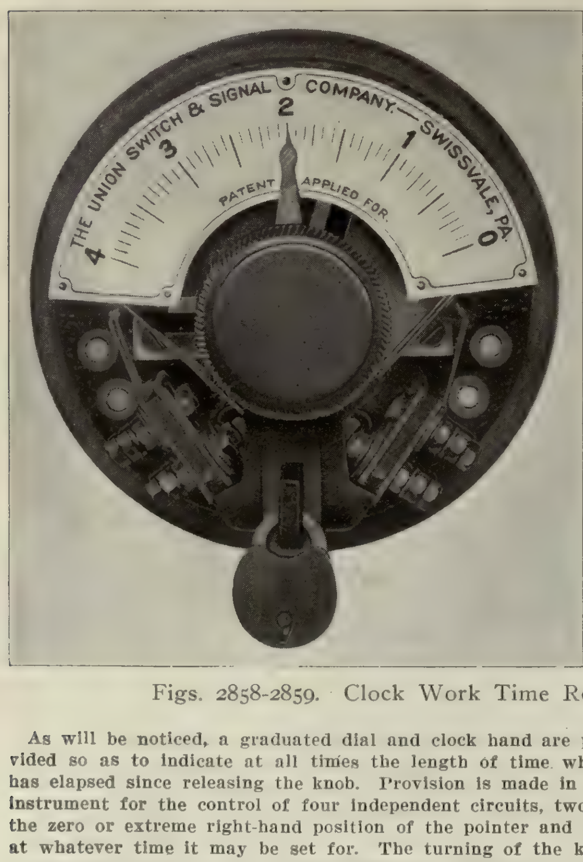
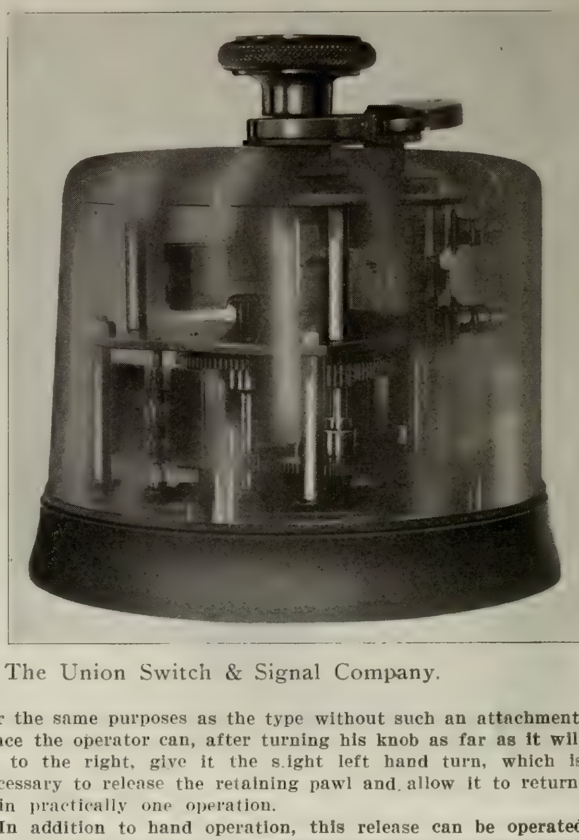


Fig. 2857. Model 2 Mechanical Hand Release Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.



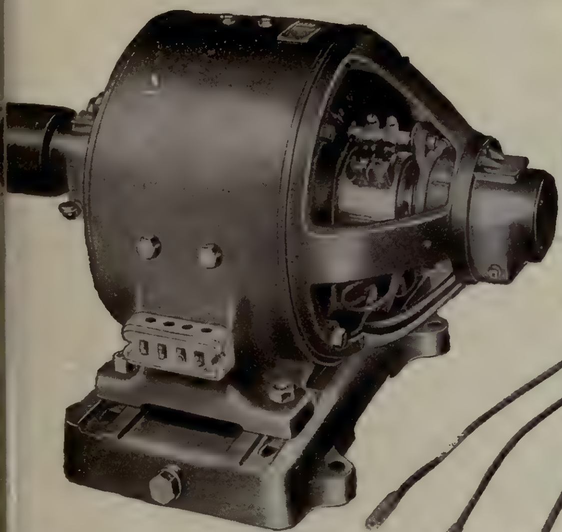


Figs. 2858-2859. Clock Work Time Release. The Union Switch & Signal Company.

As will be noticed, a graduated dial and clock hand are provided so as to indicate at all times the length of time which has elapsed since releasing the knob. Provision is made in the instrument for the control of four independent circuits, two at the zero or extreme right-hand position of the pointer and two at whatever time it may be set for. The turning of the knob to the right winds up the clock mechanism a sufficient amount always to bring the pointer back to the time for which it is desired to set the mechanism after the knob is released.

POWER GENERATION AND DISTRIBUTION

POWER UNITS AND DYNAMO MACHINERY



2860. Generator Type CVC. General Electric Company.

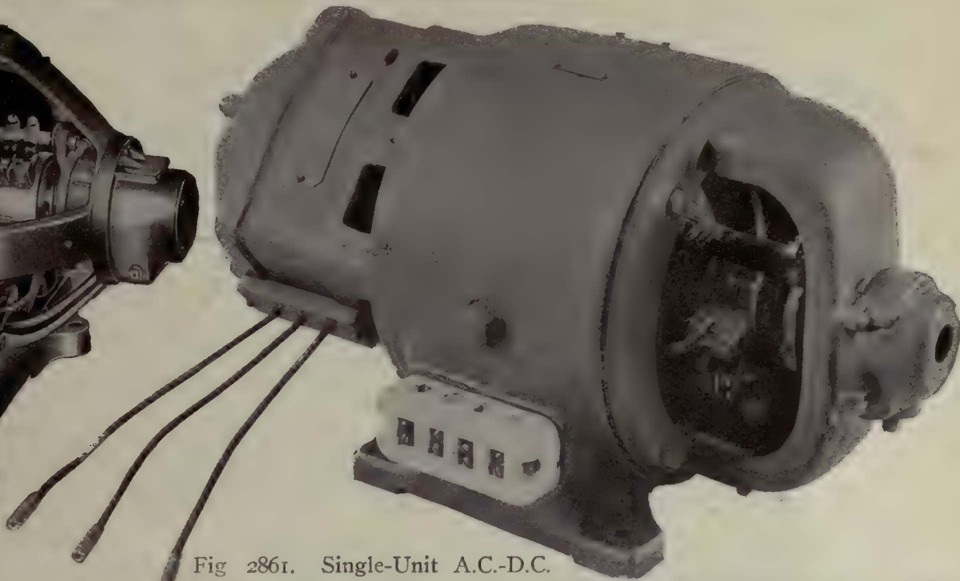


Fig 2861. Single-Unit A.C.-D.C. Motor Generator Set. Type MIC Motor. General Electric Company.

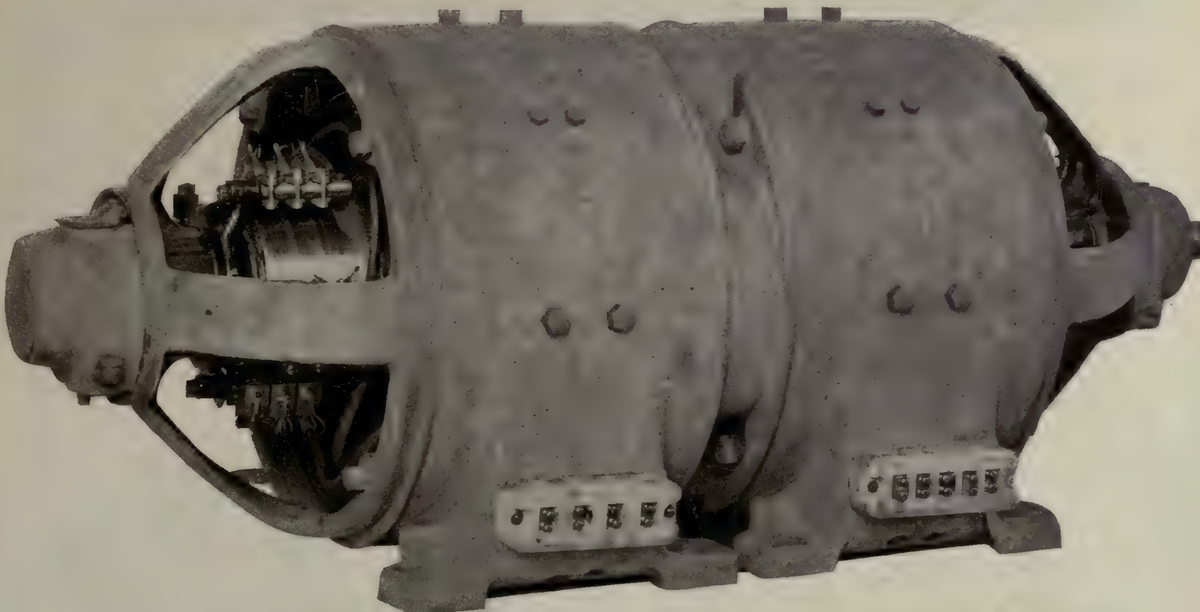


Fig. 2862. Single-Unit D.C.-D.C. Motor Generator Set, Type MCC. General Electric Company.

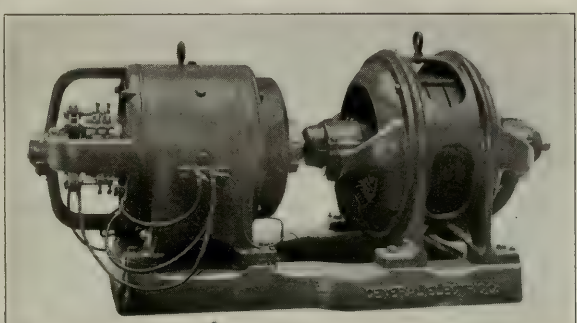


Fig. 2863. Two-Unit Motor Generator Set. General Electric Company.

Fig. 2864. Generator. General Railway Signal Company.

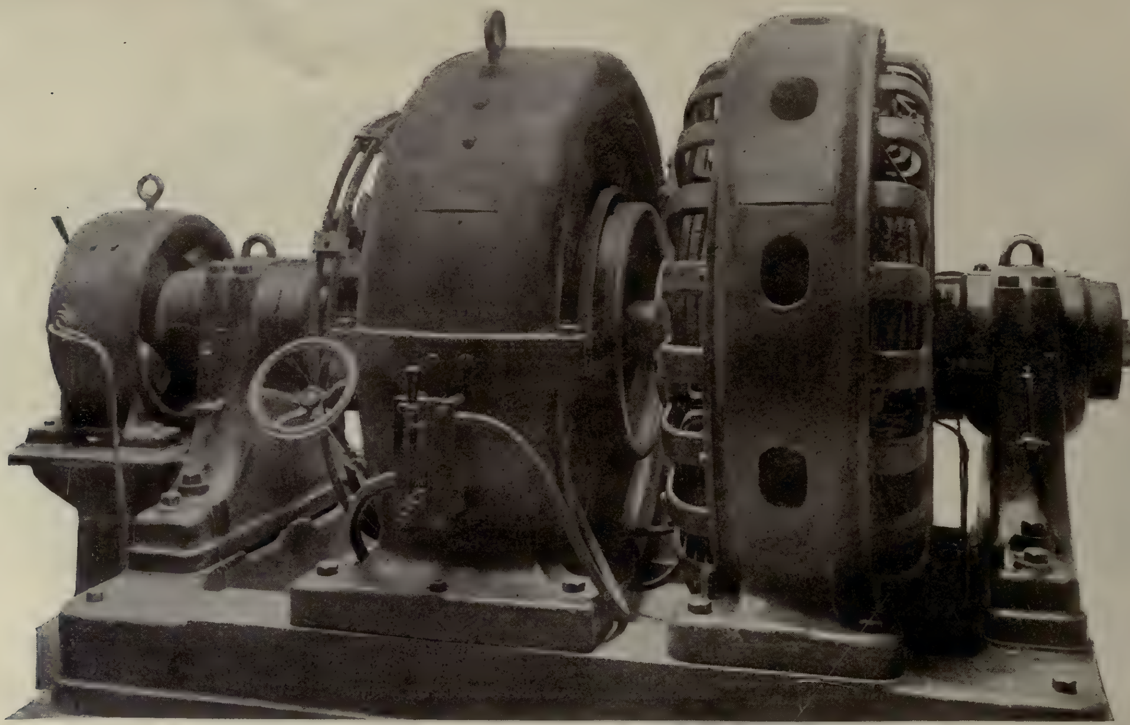


Fig. 2865. Motor Generator for Sub-Station Electric Zone. New York Central.

GASOLINE ELECTRIC GENERATOR SETS.

The General Electric Co. builds gasoline-electric generating sets for signal service in 1, 3, 5, 10 and 25 k. v. a. sizes for both direct and alternating current circuits, one, two or three-phase, 25 or 60 cycles and in standard voltages. The larger a. c. sets are designed with two fly-wheels, which feature assures more even operation, enabling sets to be operated in parallel, (see Fig. 2867).

The General Electric Co. also makes a line of small direct-connected, steam-driven generating sets, ranging in size from 2½ k. w. upwards. They are furnished in single or tandem compound types, condensing or non-condensing, and with either gravity or forced system of lubrication. These were designed originally to meet the severe conditions of marine work, which demands a light, compact, durable set, capable of close regulation and quiet operation, and are well adapted for the operation of signal systems.

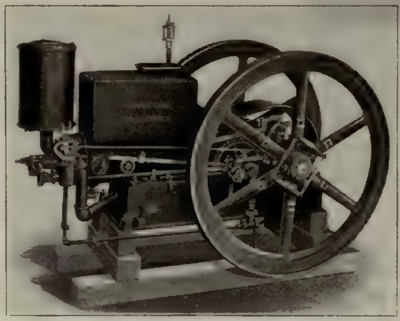


Fig. 2866. I. H. C. "Famous Mounting" Engine—Hopper Cooled—2½ to 8-H P.

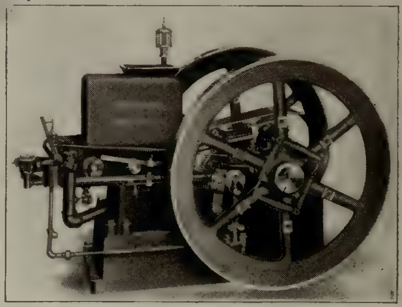


Fig. 2867. I. H. C. Victor Engine—Hopper Cooled—2½ to 8-H. P.

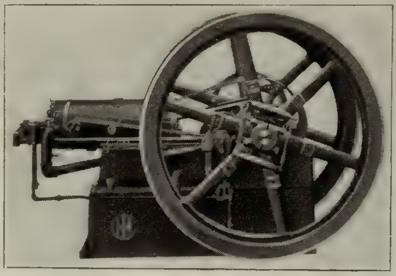


Fig. 2868. I. H. C. Victor Horizontal Engine—4 to 25-H. P.

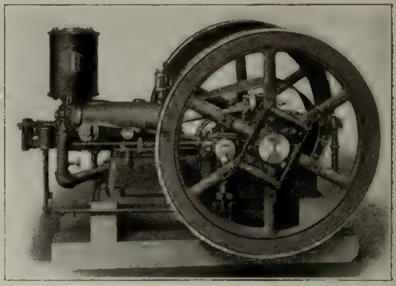


Fig. 2869. I. H. C. "Famous Mounting" Engine—Tank Cooled—4 to 20-H. P.

Figs. 2866-2869. Gasoline Engines for Generators. International Harvester Company.

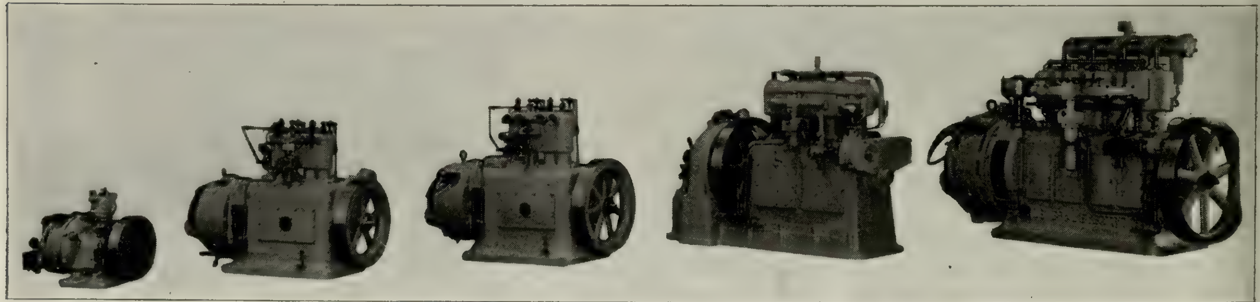


Fig. 2870. 1-3-5-10 and 25 K. W. Direct Connected Gasoline Electric Generating Sets. General Electric Company.

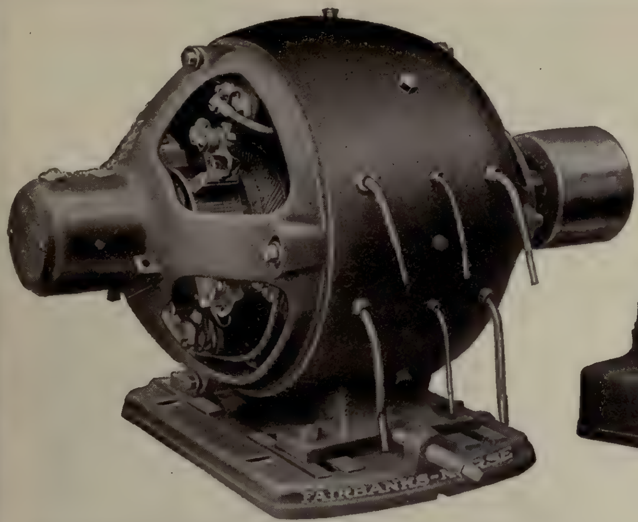


Fig. 2871. Generator. Fairbanks, Morse & Company.

Fig. 2872. Motor Generator Set. Two Bearing Type. 150 H. P., 750 P. M., 3 Phase, 50 Cycle Motor and 100 K. W., 250 Volt Generator.

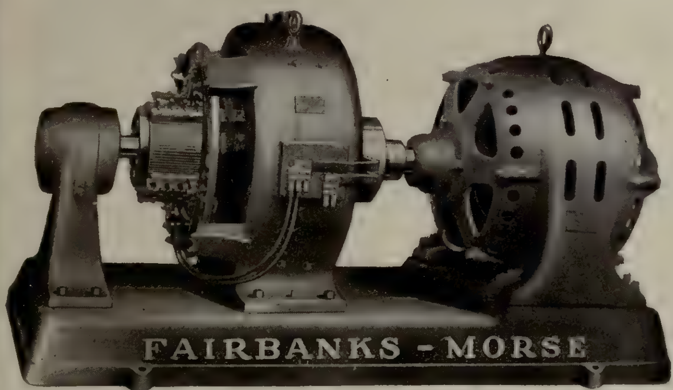


Fig. 2873. Three Bearing Motor Generator Set Converting Three-Phase Alternating Current into 115 Volts Direct Current.

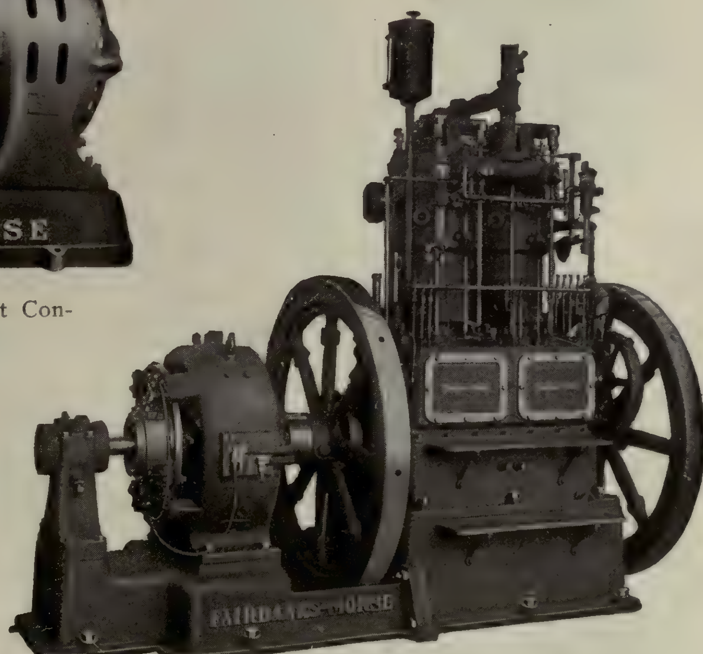


Fig. 2874. 50 H. P. Type "RE" Fairbanks-Morse Oil Engine Direct Connected to Direct Current Generator.

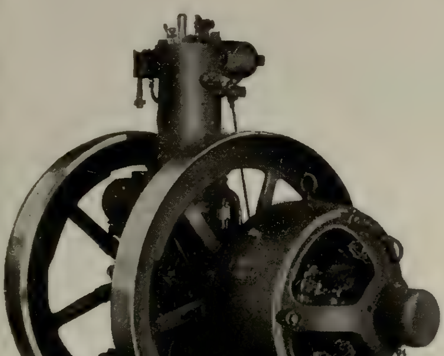


Fig. 2875. 6 H. P. Special Electric Oil Engine, Direct Connected to Fairbanks-Morse Dynamo.

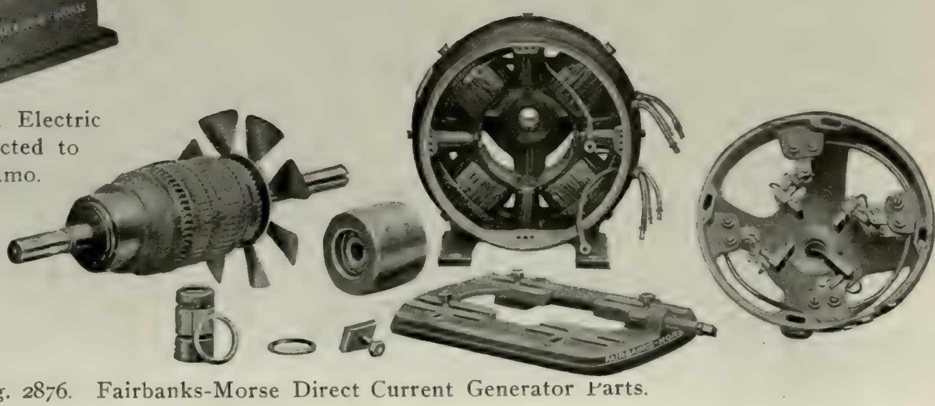


Fig. 2876. Fairbanks-Morse Direct Current Generator Parts.

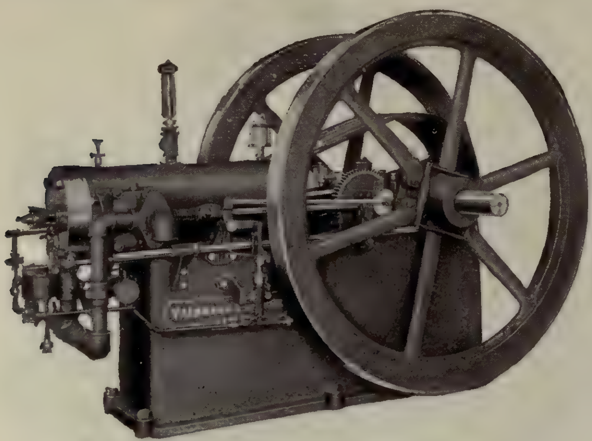


Fig. 2877. 15 H. P. Fairbanks-Morse Oil Engine.

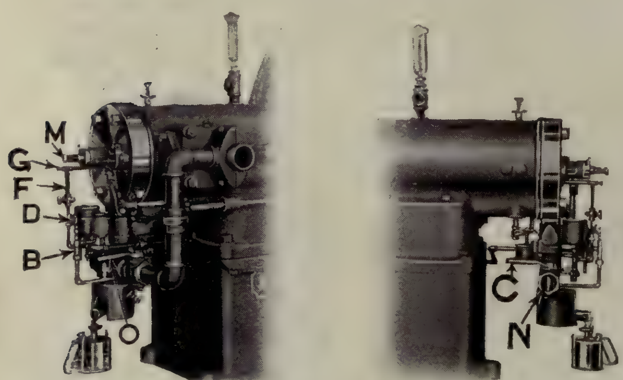


Fig. 2878. Showing Oil Engine Fittings for Oil Start. Fairbanks, Morse & Co.

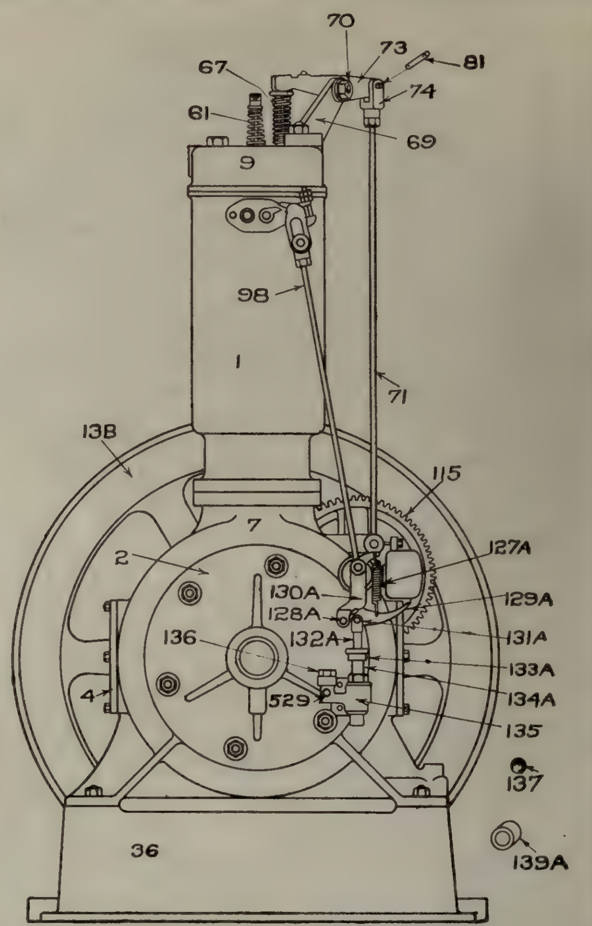


Fig. 2880. Sectional View—Fairbanks, Morse Vertical Gas and Gasoline Engine.

Names of Parts of Vertical Gas Engine. Fig. 2880.

1	*Cylinder*	9	*Cylinder Head*
2	*Base*	13B	*Flywheel*
4	*Base Cap*	36	*Lower Base*
61	*Suction Valve Spring*		
67	*Exhaust Valve Spring*		
69	*Exhaust Rocker Lever Bracket*		
70	*Exhaust Rocker Fulcrum*		
71	*Exhaust Rod*		
73	*Exhaust Rocker Lever*		
74	*Exhaust Rod End Jaw*		
81	*Exhaust Rod End Pin*		
98	*Igniter Rod*		
115	*Governor Gear*		
127A	*Fuel Pump Link Spring*		
128A	*Link and Lever Pin and Cotters*		
129A	*Fuel Pump Lever*		
130A	*Fuel Pump Link*		
131A	*Plunger Pin and Cotters*		
132A	*Fuel Pump Plunger*		
133A	*Fuel Pump Barrel Cap*		
134A	*Fuel Pump Barrel*		
135	*Valve Chamber*		
136	*Valve Chamber Cap*		

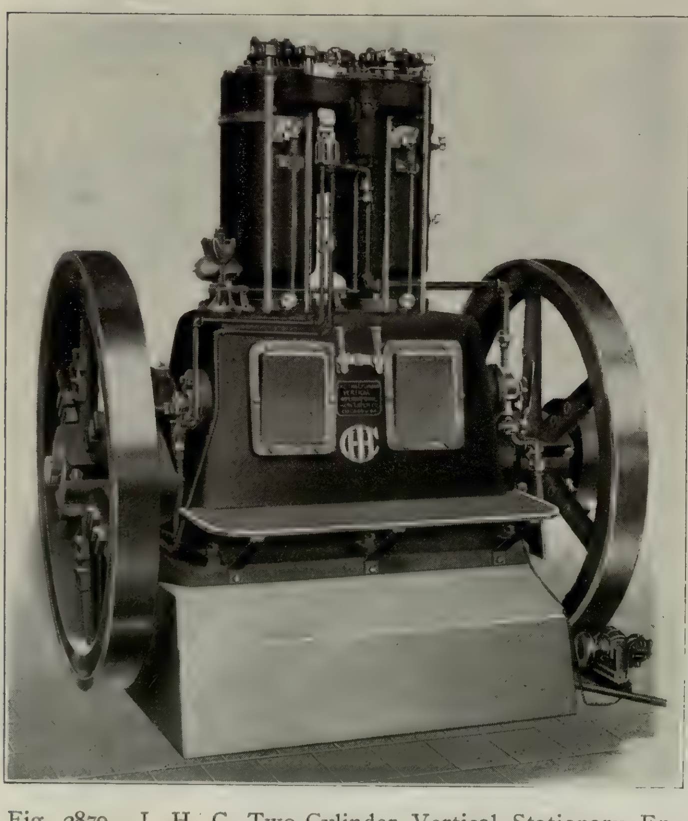


Fig. 2879. I. H. C. Two-Cylinder Vertical Stationary Engine Regulated to 2 Per Cent Speed Variation. 24 and 35 H. P. International Harvester Company.

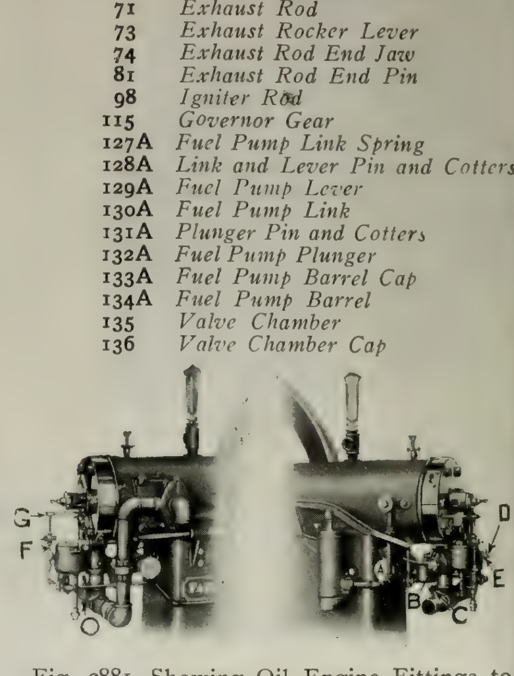


Fig. 2881. Showing Oil Engine Fittings to Start on Gasoline and Run on Oil. Fairbanks, Morse & Co.

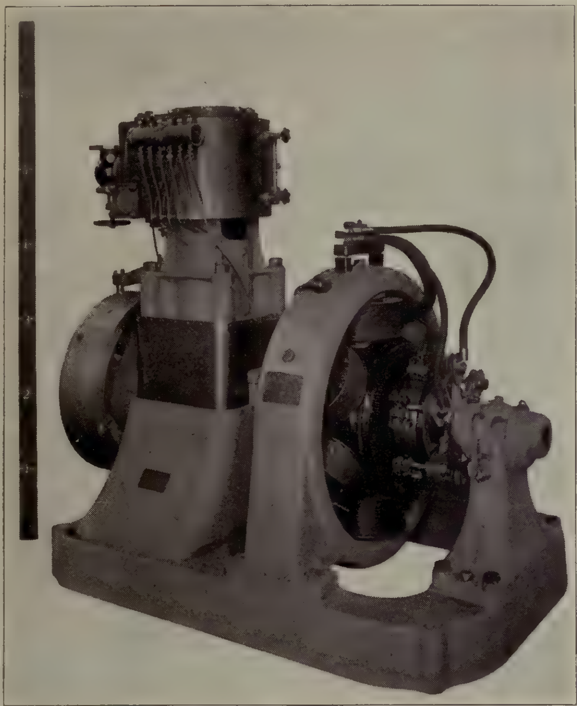


Fig. 2882. D. C. Generator Direct Connected to a Single Cylinder Engine Having a Gravity System of Lubrication. General Electric Company.

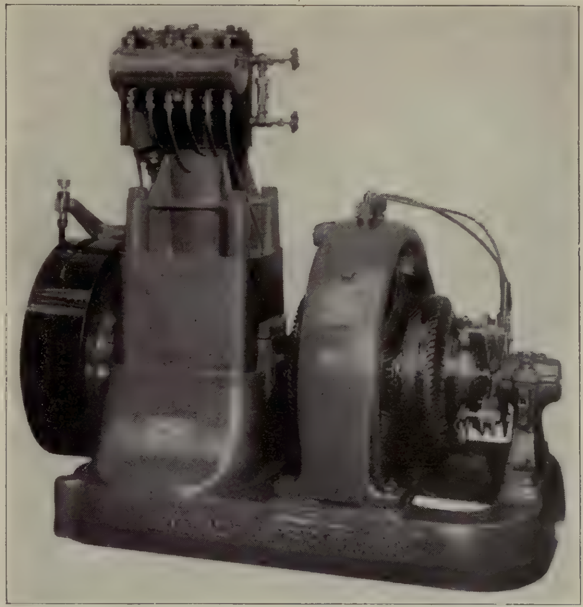


Fig. 2884. 10-KW. D. C. Generator Direct Connected to Single Cylinder Gravity Lubrication Engine. General Electric Company.

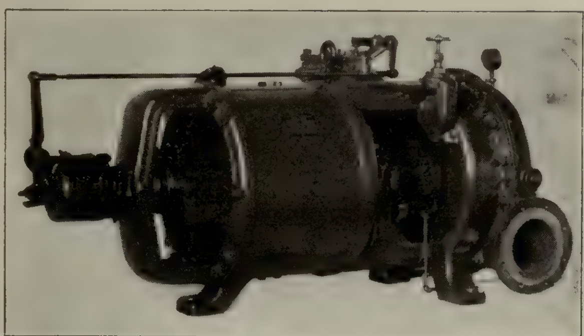


Fig. 2883. 15-K. W. Direct Current Steam Turbine Set. General Electric Company.

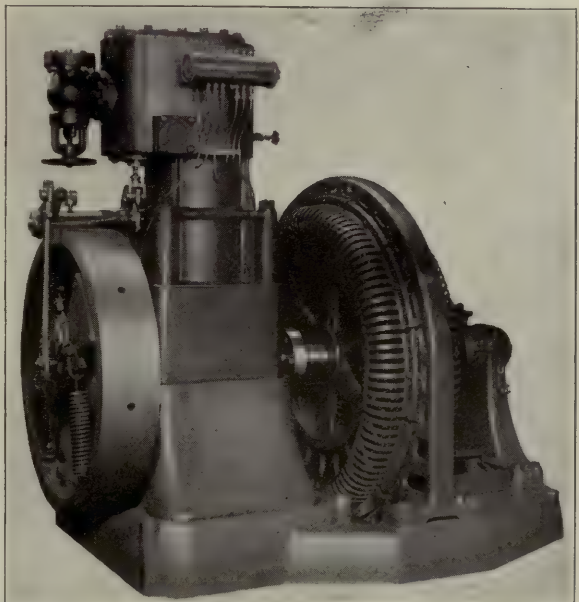


Fig. 2885. 50-KVA, A. C. Generator with Single Cylinder Form "K" Engine. Gravity System of Lubrication. General Electric Company.

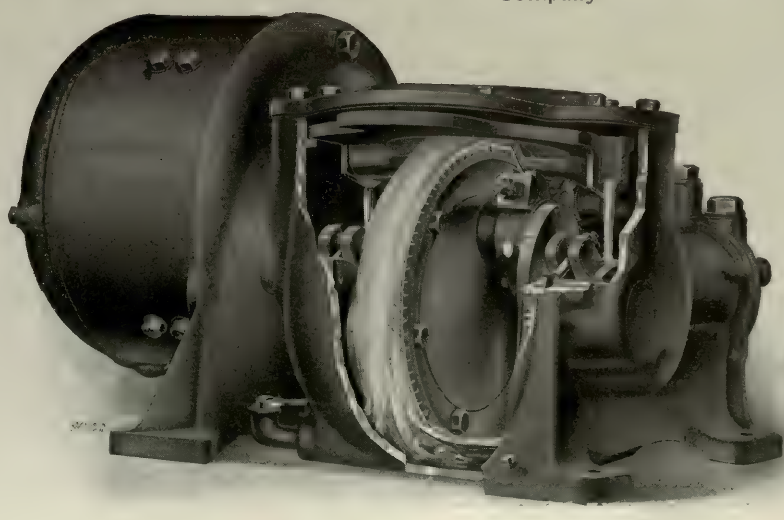


Fig. 2886. Direct Connected Steam Turbine Generating Set. General Electric Company.

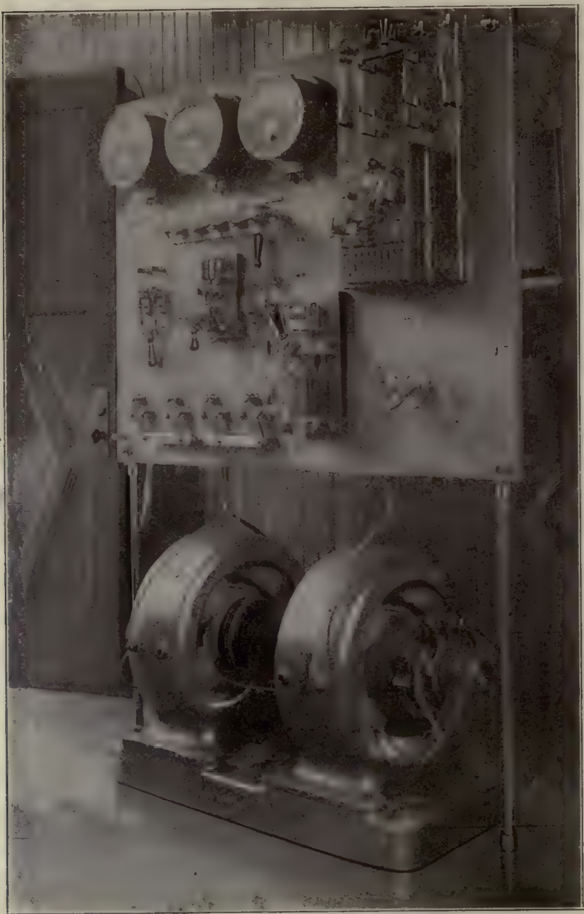


Fig. 2887. Switchboard and Motor Generator Set. Boston Elevated.

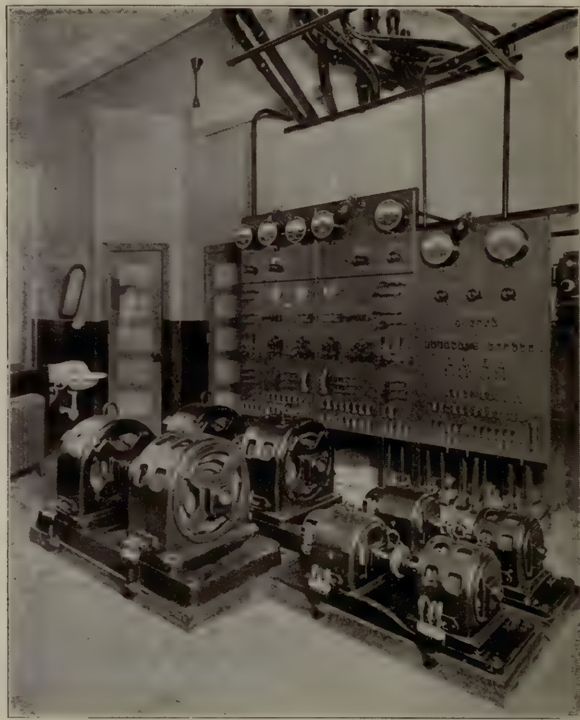


Fig. 2888. Motor Generator Sets in Interlocking Plant, Chicago Terminal. Chicago & North-Western.

C. & N. W. TERMINAL POWER SYSTEM.

In the power distributing system on the Chicago & North-Western passenger terminal in Chicago power for all uses except the operation of one of the five plants is taken from the power house at 6,600 volts, three phase, and distributed through a conduit system. The current is transformed to 220 volts, three phase for power purposes, and to 220 volts—110 volts single phase for lighting purposes. Transformers located near each tower supply current for the towers, and also for the nearby signal bridges. The remaining transformers are so located as to supply two or more outlying signal bridges. The lighting transformers are arranged in pairs, with secondaries in multiple so that there are two sources of power for each circuit, either transformer being able to carry the total load. Induction-motor

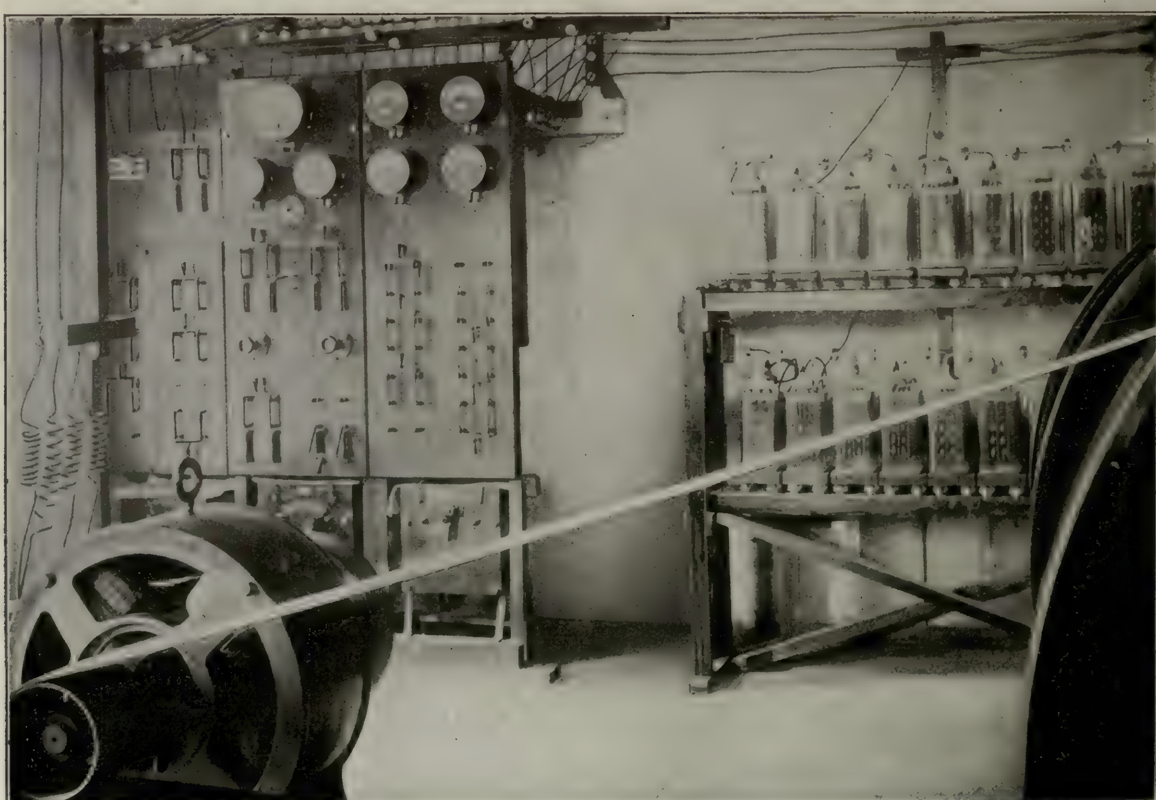


Fig. 2889. Power Room for Electric Interlocking Plant. Federal Signal Company.

generator sets are provided in duplicate for each battery located in the towers. The generators are shunt wound with wide variation of voltage. A motor generator is running continuously in multiple with each battery, taking most of the load, the battery helping out on the peaks. Automatic underload circuit breakers are provided for opening the generator circuits in case of failure of the alternating current supply. All motor generators are of the same type, the voltage range being from four to 40. The generators are capable of charging from one to 16 cells of battery.

Current for the lever locks of the interlocking machines is supplied from a 220 to 55 volt transformer and the illuminated track diagram is fed from a 220 to 14, 12, and 10 volt transformer. If the alternating current fails an emergency switch will connect up the locks, and the plants are then operated without the diagrams.

At one plant (Lake street plant) power is received from three single-phase transformers delta connected, located in the power house and furnishing 320 volts.

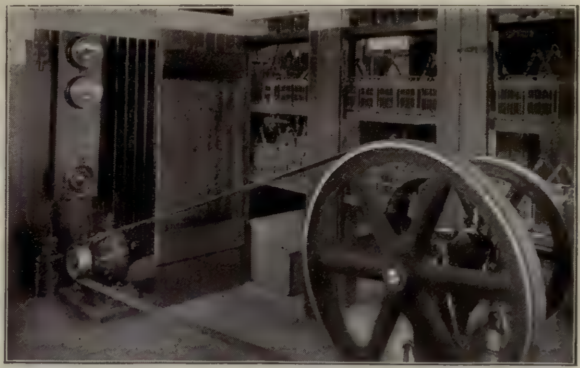


Fig. 2889. Interlocking Plant Power Room Equipment. Southern Pacific.

POWER SWITCHBOARDS

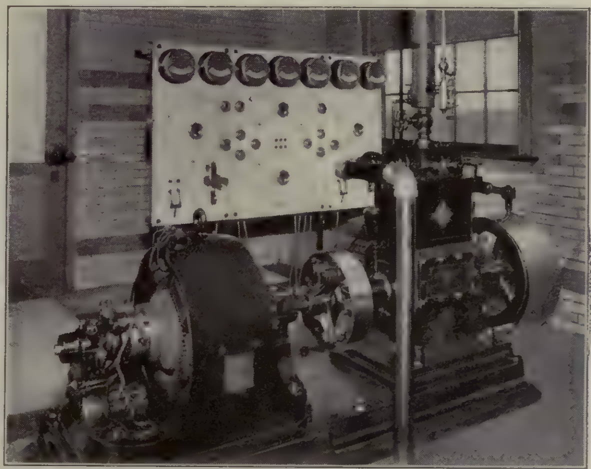


Fig. 2891. Interlocking Plant Power Room Equipment. Pennsylvania Railroad.

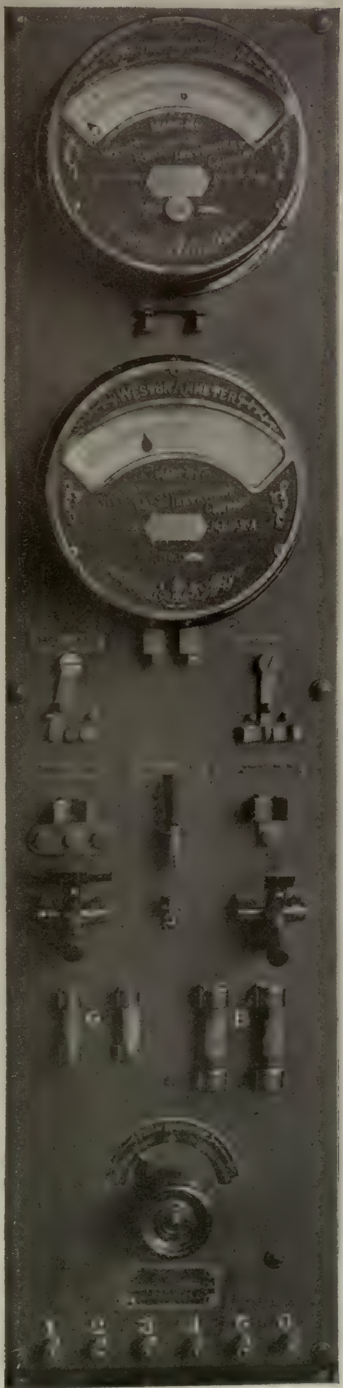


Fig. 2890. Power Switchboard Panel. General Railway Signal Company.

Fig. 2892. Switchboard for Electric Interlocking Plant. New York, New Haven & Hartford. The Union Switch & Signal Company.

Fig. 2893. Power Switchboard. American Railway Signal Company.

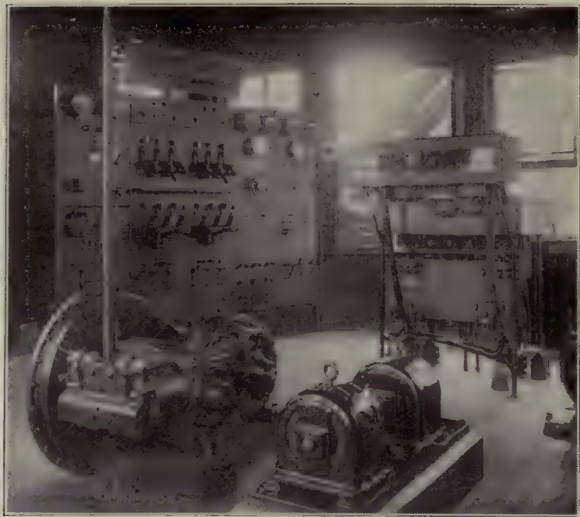


Fig. 2894. Arrangement of Switchboards and Generating Apparatus. S. P. & S. R. R. General Railway Signal Company.

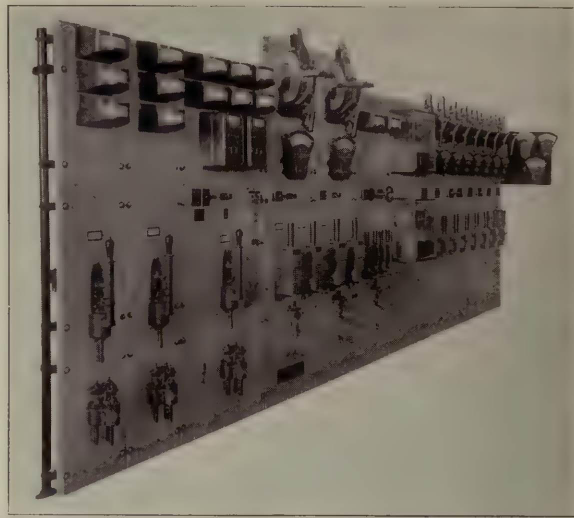


Fig. 2895. A. C. and D. C. Switchboard Installed on the New York Central. General Electric Company.

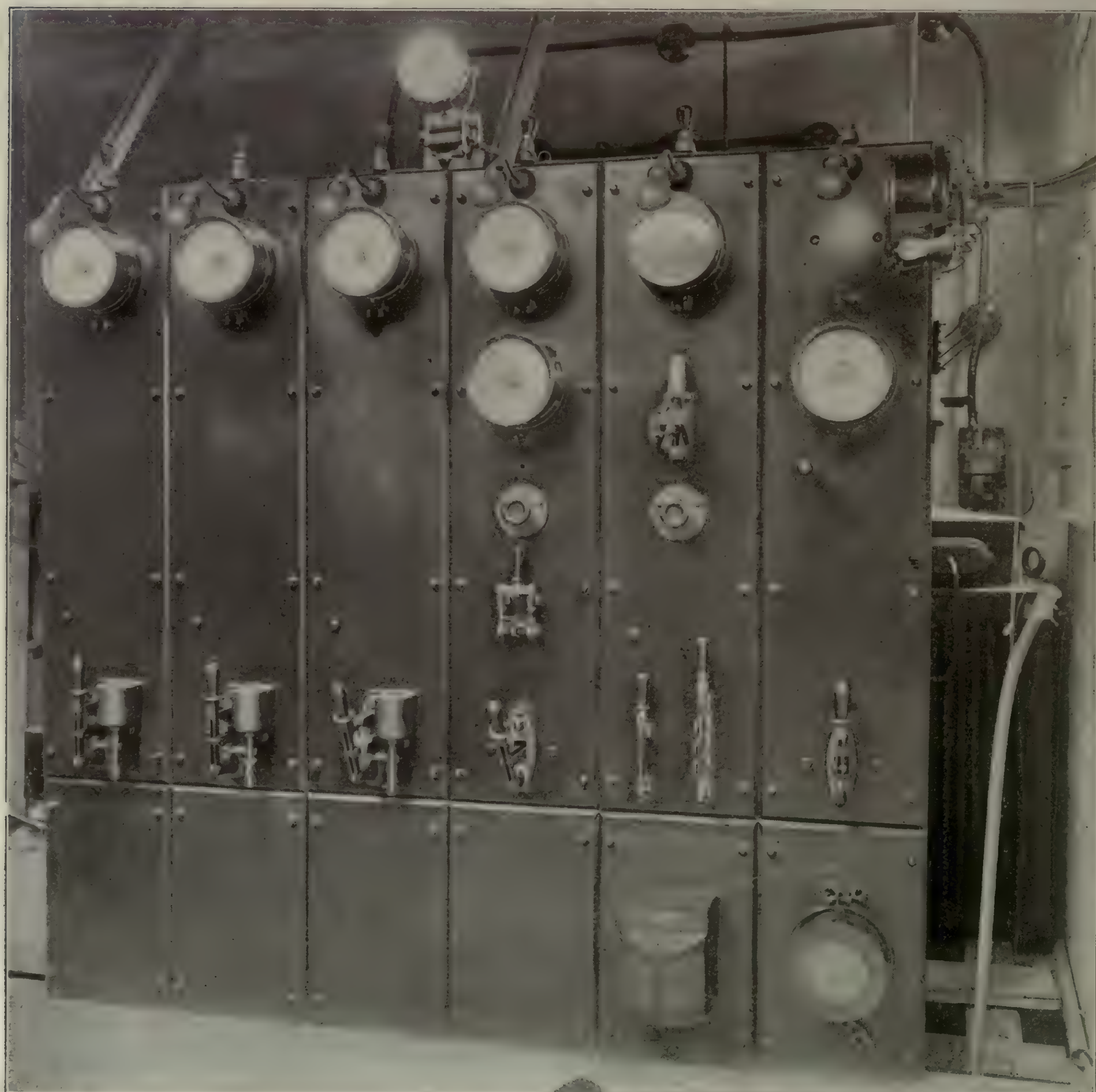


Fig. 2896. Switchboard for Sub-Station as Furnished for the Electric Zone of the New York Central & Hudson River by the General Railway Signal Company.

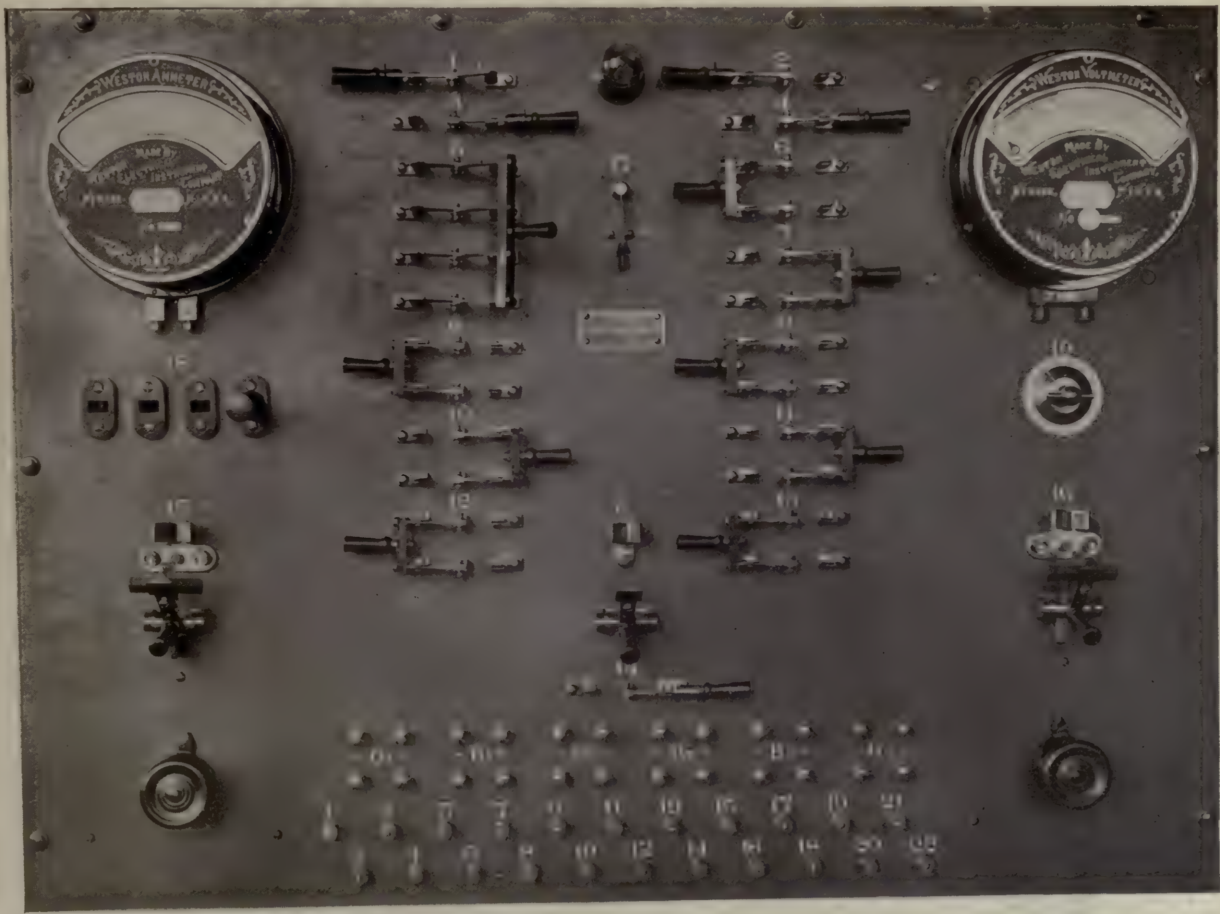


Fig. 2897. Front View of Power Switchboard. General Railway Signal Company.

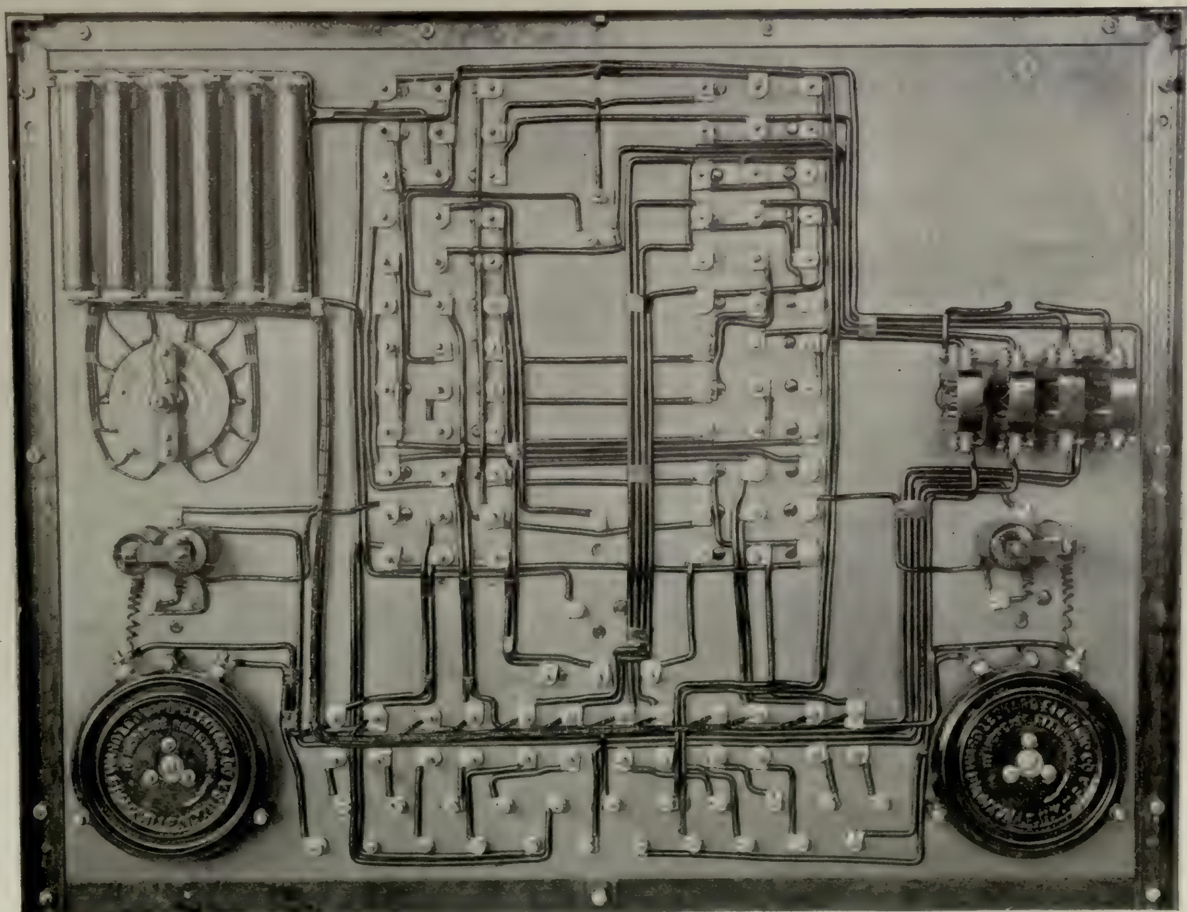


Fig. 2898. Rear View of Power Switchboard. General Railway Signal Company.

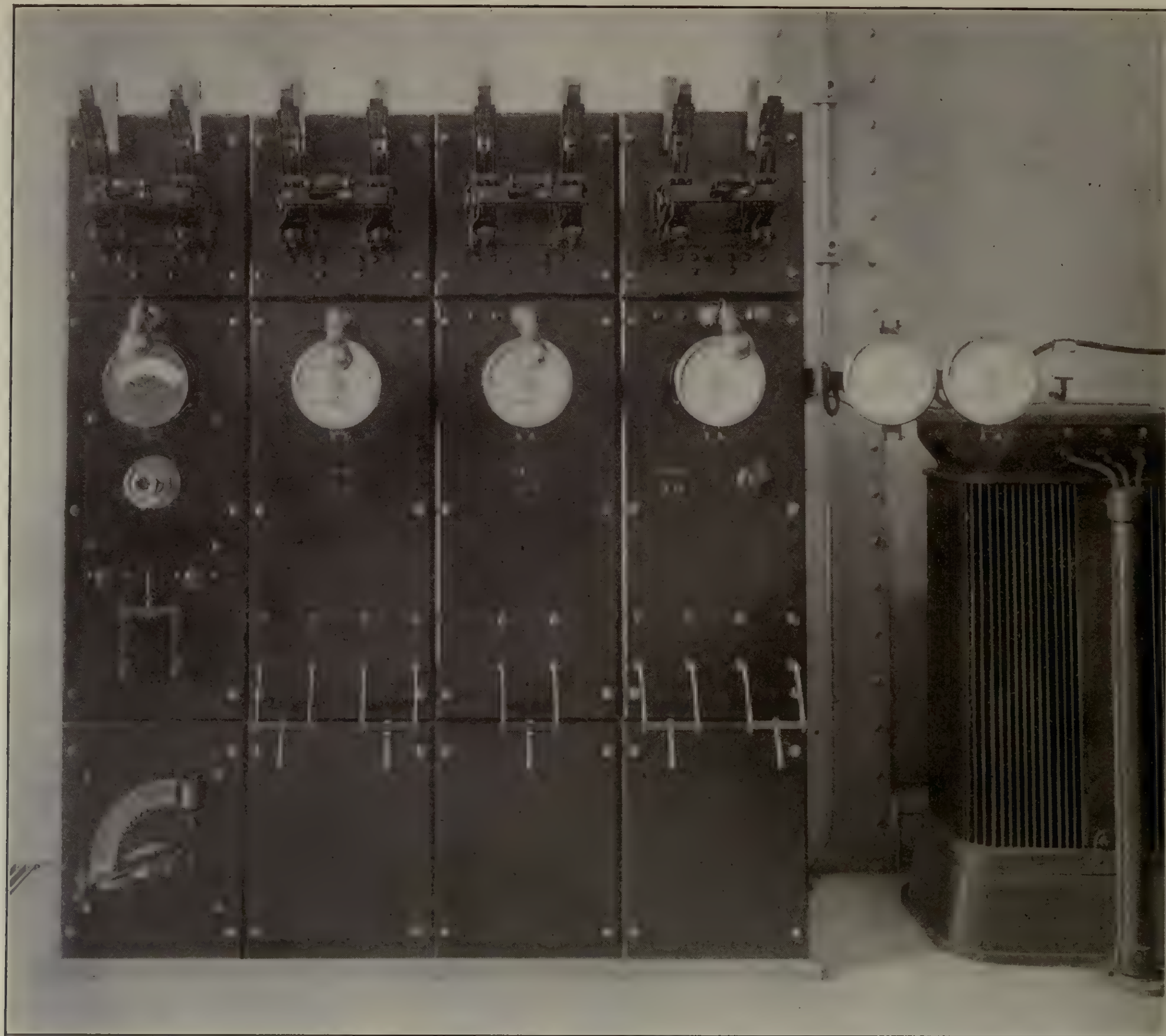


Fig. 2899. Switchboard for Alternating Current Track Circuit Block Signal System. Interborough Rapid Transit Company. The Union Switch & Signal Company.

MERCURY ARC RECTIFIERS.

GENERAL ELECTRIC MERCURY ARC RECTIFIER.

The mercury arc rectifier consists, as its name implies, of a mercury vapor arc. This arc is enclosed in an exhausted glass vessel of peculiar construction, which can be seen in the center of the switchboard, Figs. 2903-2905, and in Fig. 2909.

Mercury vapor in its ordinary or molecular condition is practically a non-conductor of electricity. Such vapor might be formed by applying heat to a mass of mercury enclosed in a vacuous chamber. If a body of vapor thus formed were subjected to the action of an electromotive force, either continuous or alternating, its resistance would be found to be very great. If, however, the mercury vapor is ionized, in other words, if the atoms of mercury in this vapor are electrified, the electrical resistance to the flow of current in one direction will be very small, while its resistance to current flowing in the opposite direction will still be great. To use a very crude analogy, its action on an electric current is similar to the action of a check valve on a current of water flowing through a pipe.

The ionization of mercury vapor is easily accomplished. If an arc is formed between one mercury electrode and another electrode, the mercury being the negative, ionized mercury vapor will result. When a mercury arc is formed, as in the mercury arc lamp, the negative electrode being mercury, the resistance of this arc is small, but only to current of one direction. Hence it is seen that the current in a mercury arc must be uni-directional. This brings us to an understanding of the action of the rectifier. A mercury cathode is provided and two anodes of suitable material are connected across the terminals of an alternating current circuit, thus becoming alternatively positive and negative. The arc shifts from one anode to the other with each alteration, always passing from a positive anode to the negative cathode. The current in the wire connected to the cathode is, therefore, always in the same direction.

The direct current delivered by the mercury arc rectifier is very different in its characteristics from that delivered by a

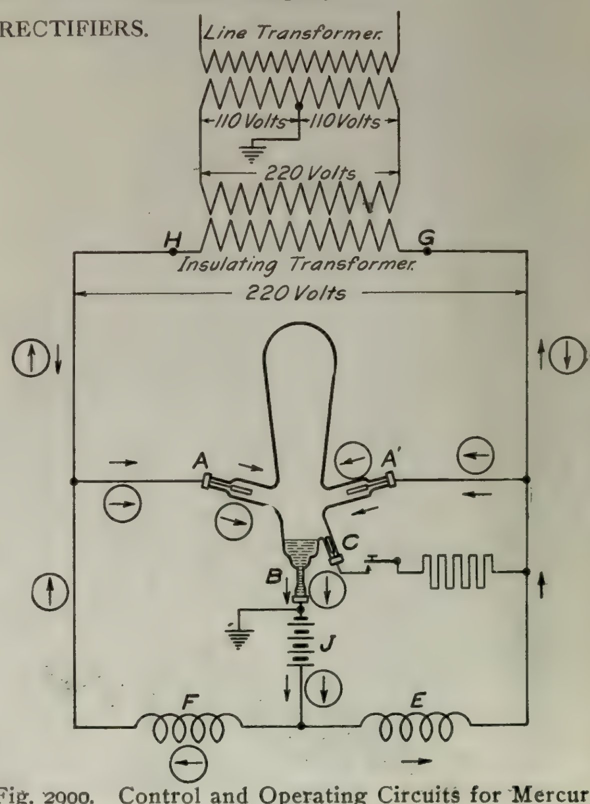


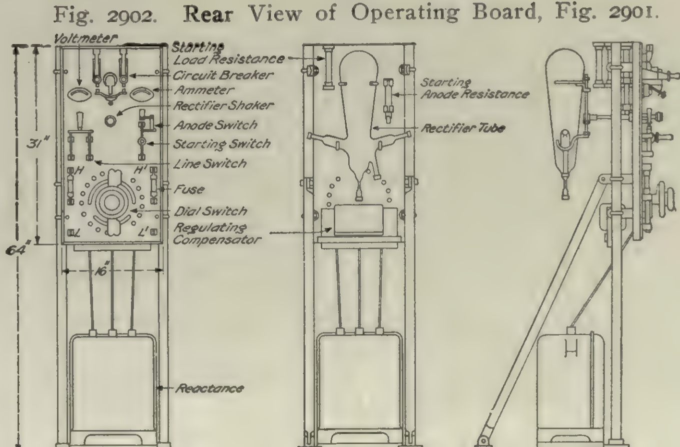
Fig. 2900. Control and Operating Circuits for Mercury Arc Rectifier.

synchronously driven rectifier. The current from a synchronously driven machine consists of a series of pulsations, each separated from the others by a certain small interval. If we were able to operate a mercury arc rectifier, in accordance with the above theoretical considerations, without any accessory apparatus, this rectified current would be composed of a series of pulsations, but would lack the separating gaps mentioned, the current wave being similar in form to the impressed alternating current wave, with the exception that the negative half would be transposed, so as to become positive with reference to the zero line. This, however, is not the case.

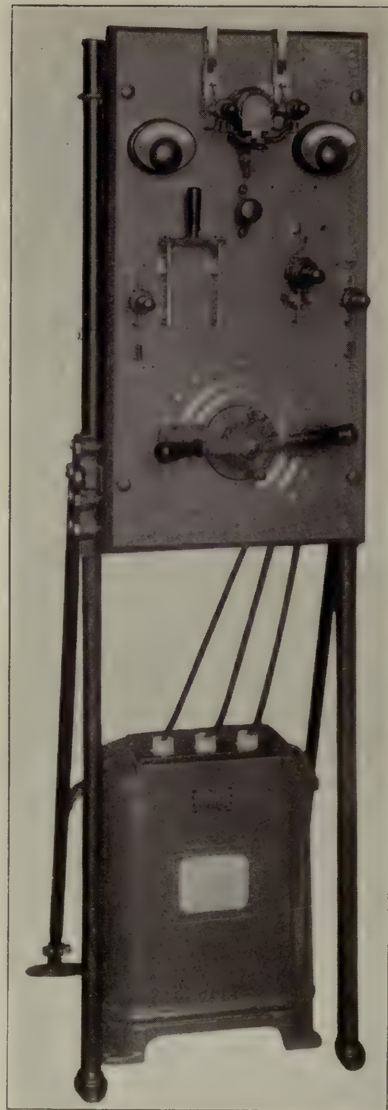
All types of mercury arc rectifiers have three essential parts, the rectifier tube, the main reactance and the panel. The rectifier tube is an exhausted glass vessel in which are two graphite electrodes (anodes A-A′), Fig. 2900, and one mercury cathode (B). Each anode is connected to a separate side of the alternating current supply, and also through one-half of the main reactance to the negative side of the load. The cathode is connected to the positive side. There is also a small starting electrode (C) connected to one side of the alternating current circuit through resistance, and used for starting the arc. When the rectifier tube is rocked, so as to form and break a mercury bridge between the cathode (B) and the starting anode (C), a slight arc is formed. This starts what is known as the "excitation" of the tube, and the cathode begins supplying ionized mercury vapor. This condition of excitation can be kept up only as long as there is current flowing toward the cathode

Fig. 2901. Front View of Mercury Arc Rectifier Operating Board. General Electric Company.

Fig. 2902. Rear View of Operating Board, Fig. 2901.



Figs. 2903-2905. Mercury Arc Rectifier and Operating Board. General Electric Company.



Figs. 2906-2907. Standard Battery Charging Rectifier Set. General Electric Company.

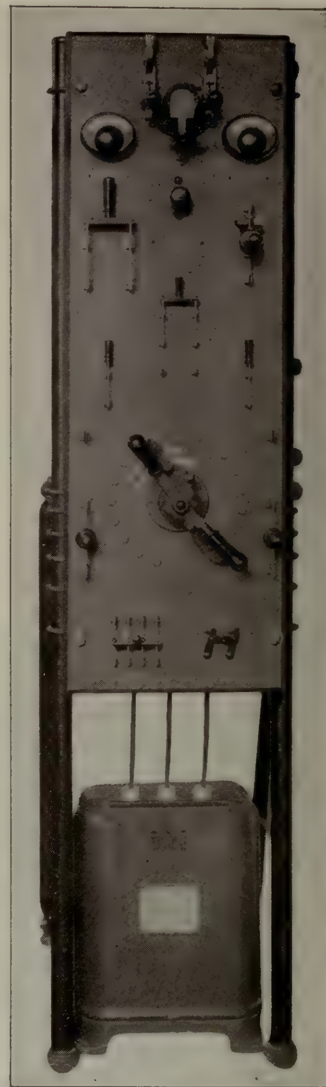


Fig. 2908. Single-Phase Mercury Arc Rectifier for Use with Railway Signal Batteries.

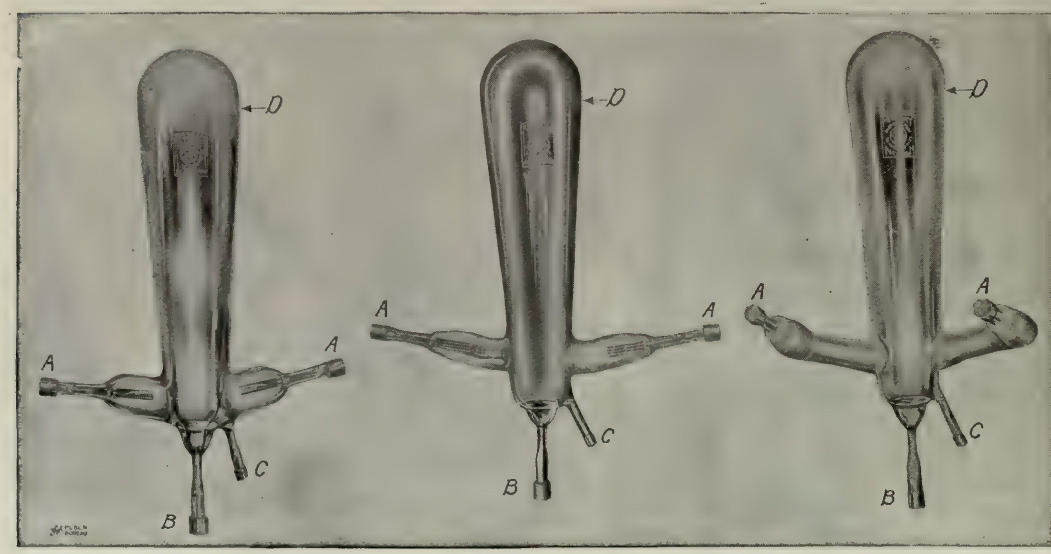


Fig. 2909. Mercury Arc Rectifier Tubes.

Names of Parts of Mercury Rectifier Tubes; Fig. 2909.

A *Anode.*
B *Cathode.*
C *Starting Anode.*
D *Mercury Vapor Tube.*

If the direction of supply voltage is reversed, so that the formerly negative electrode, or cathode, becomes positive with the reversal of the alternating current circuit, the current ceases to flow; since, in order to flow in the opposite direction, it would require the formation of a new cathode, which can be accomplished only by special means. Therefore, in the rectifier tube, the current must always flow toward the cathode which is kept in a state of excitation by the current itself.

Such a tube would cease to operate on alternating current voltage after one-half the cycle, if some means were not provided to maintain the flow of current continuously toward the cathode.

The maintenance of the current flow is accomplished by the main reactance. As the current alternates, first one anode and then the other becomes positive, the current flowing from the positive anode through the mercury vapor, toward the cathode, thence through the battery, or other load, and back through one half of the main reactance to the opposite side of the alternating current supply circuit. As the current flows through the main reactance, it charges it, and while the value of the alternating wave is decreasing, reversing and increasing the reactance discharges, thus maintaining the arc until the voltage reaches the value required, to maintain the current against the counter e. m. f. of the load, and reducing the fluctuations in the direct current. In this way, a true continuous current is produced with very little loss in transformation.

That there may be no misapprehension, it should be particularly noted that the rectifier is so designed that the entire alternating current wave is used. This, of course, means that the rectifier has approximately twice the efficiency that would be obtained if only one-half or the alternating current wave were used.

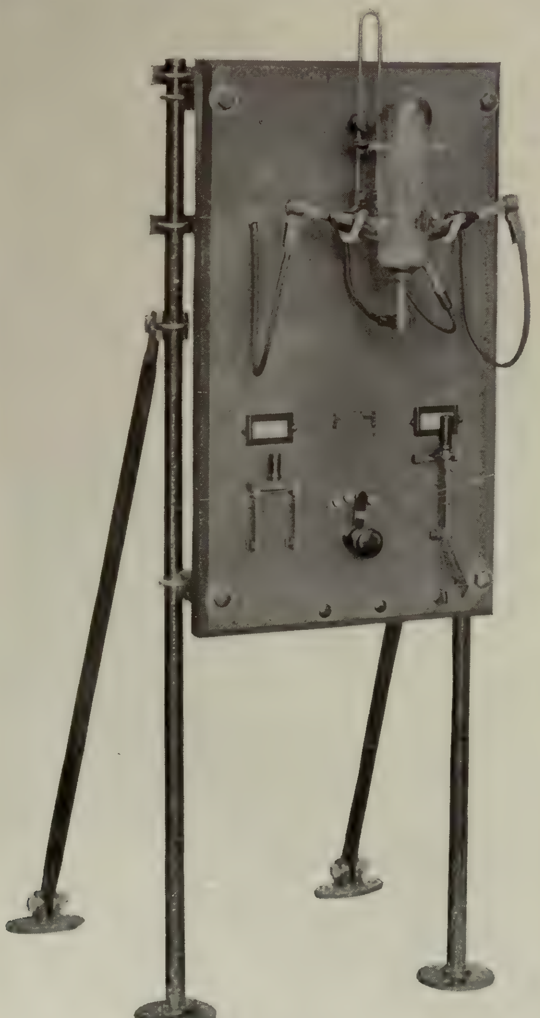
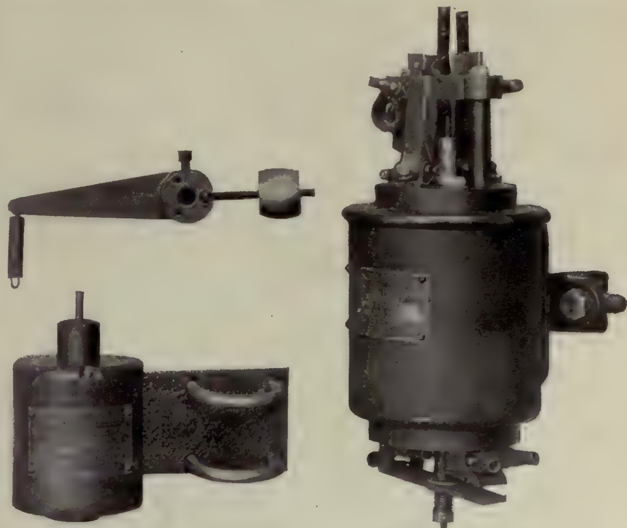


Fig. 2910. Mercury Arc Rectifier Mounted on Front of Operating Board. General Electric Company.

To get an idea of the operation of the mercury arc rectifier, assume that the instant the terminal "H" of the supply (or insulating) transformer is positive, the anode "A" is then positive, and the arc is free to flow between "A" and "B." Following the direction of the arrow still further, the current passes through the battery "J," through one-half of he main reactance coil "E," and back to the negative terminal "G" of the transformer. When the impressed e. m. f. falls below a value sufficient to maintain the arc against the counter e. m. f. of the arc and load, the reactance "E," which hereto has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc



Figs. 2911-2913. Control Apparatus for Mercury Arc Rectifier. General Electric Company.

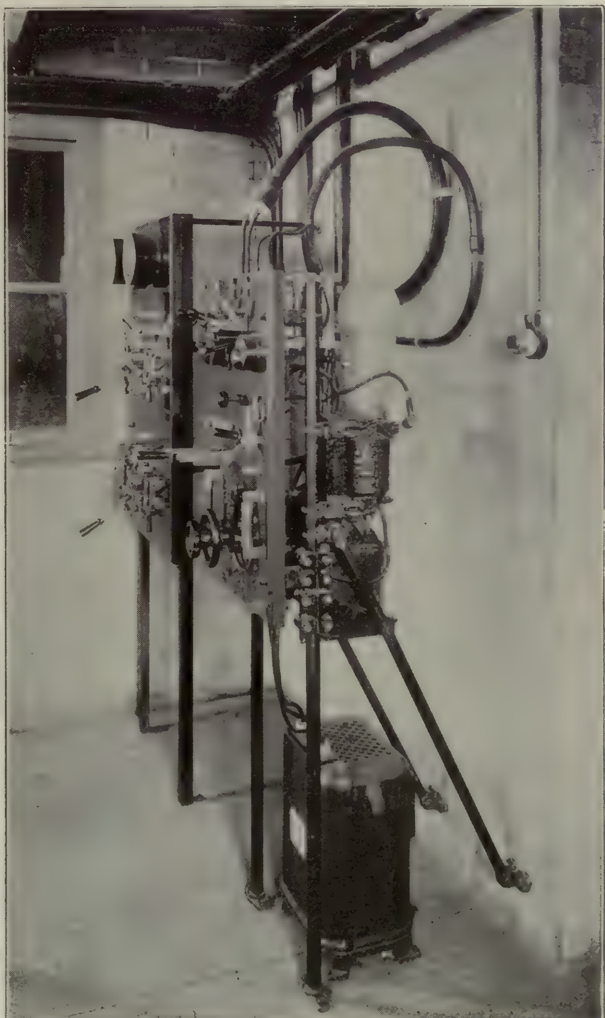


Fig. 2914. Rectifier Outfit at Communipaw, N. J., Electro-Pneumatic Interlocking Plant. Central R. R. of New Jersey.

in the rectifier tube until the e. m. f. of the supply has passed through zero, reversed, and built up to such a value as to cause the anode "A" to have sufficient positive value to start the arc between it and the cathode "B." The discharge circuit of the reactance coil "E" is now through the arc "B" instead of through its former circuit. Consequently the arc A'B is now supplied with current, partly from the transformer, and partly from the reactance coil "E." The new circuit of the transformer is indicated by the arrows enclosed in circles.

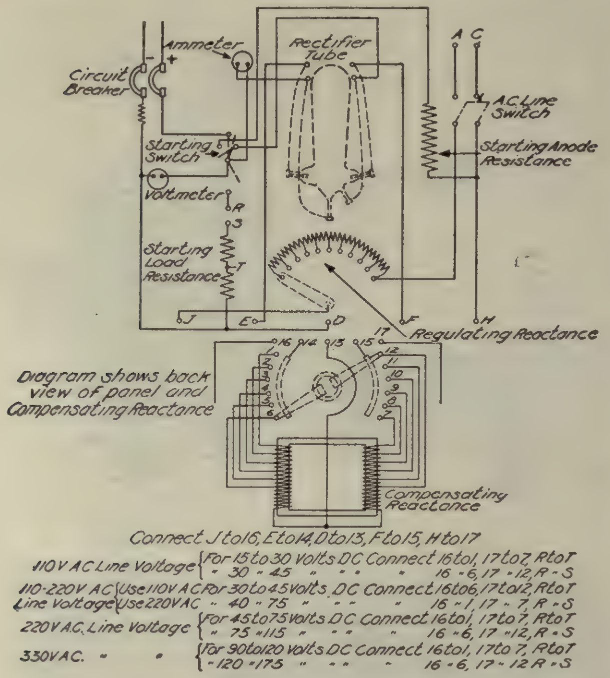


Fig. 2915. Control and Operating Circuits for Mercury Arc Rectifier. General Electric Company.

The rectifier set shown in Fig. 2906 requires a floor space of approximately 16 in. x 18 in. and has a height of 64 in. On the panel are mounted a direct current voltmeter and ammeter, a double pole switch for connecting the supply circuit, a direct current overload circuit breaker for the load, and the necessary switches for starting the rectifier and regulating the charging current. A starting resistance on which the rectifier starts before connection to the battery, is mounted on the back of the panel and is operated by a single pole, double-throw spring switch on the front.

Accurate voltage control is obtained by means of a double regulating switch on the front of the panel. This switch has two sets of contact buttons—six in one set for rough regulation and eleven in the fine regulation set. It is possible to obtain a very wide regulation, practically independent of the current flowing. The contact buttons are connected to rough and fine regulation taps brought out from the regulating compensator mounted on the back of the panel.

The rectifier tube differs in size according to the ampere capacity, and in shape according to the direct current voltage at which it is to be used.

The terminals of the rectifier tubes are provided with metal caps for the protection of the electrodes from mechanical injury and for convenience in making connections. The rectifier tube is supported at the back of the tube by a metal holder, so pivoted and connected that it can be rocked back and forth by the small hand-wheel on the front of the board.

The reactance which maintains the arc at each reversal of the alternating current is connected directly across the secondary of the regulating compensator. It is mounted in a cast iron case and stands on the floor beneath the panel.

AIR COMPRESSORS

GENERAL ELECTRIC AIR COMPRESSORS.

The General Electric Co.'s air compressors are single acting, single stage, with horizontal cylinders. Connection to the motor is made through a gear and pinion having accurately cut herringbone teeth. The frame casting completely encloses all working parts of the compressor and contains both the motor and crank-shaft bearings. Securely bolted to this frame is the motor frame. The gear is located in the middle of the crank shaft and the gearing is entirely enclosed in the crank case, this feature eliminating the necessity of a separate gear case.

All bearings and working parts are automatically lubricated from a well formed in the compressor frame, immediately below the gear.

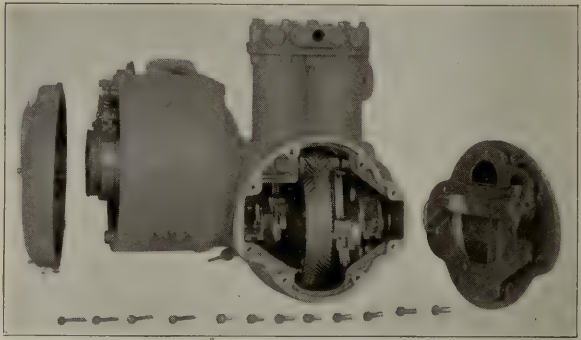


Fig. 2916. Motor Driven Air Compressor with Motor and Compressor Covers Removed. General Electric Company.

Figs. 2918-2919. Expansion Joint for Condenser. The Union Switch & Signal Company.

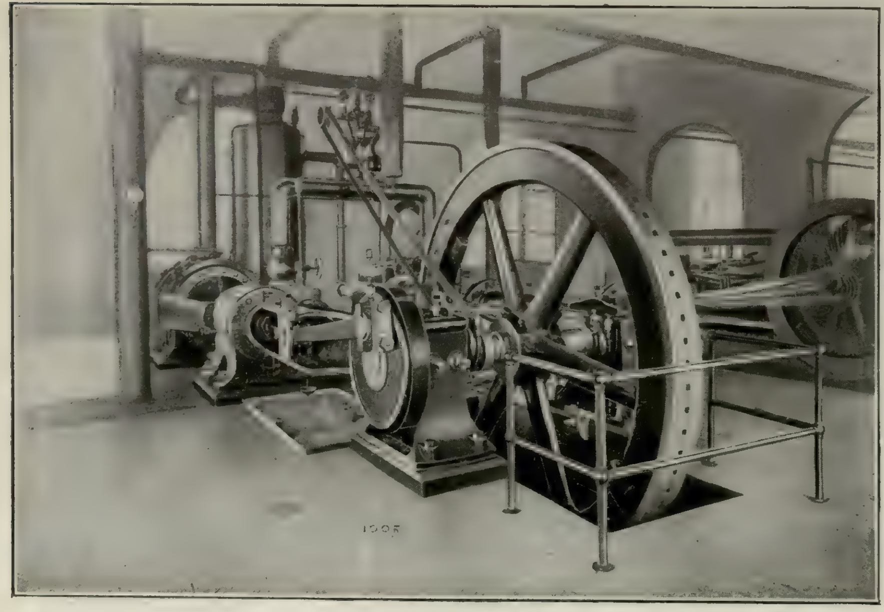


Fig. 2917. Ingersoll-Sergeant Air Compressor. Terminal Railway Association of St. Louis.

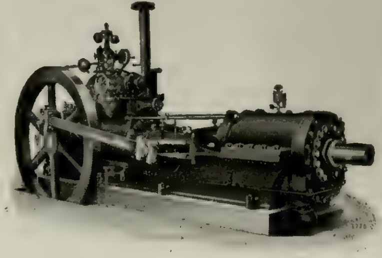


Fig. 2920. Ingersoll-Sergeant "Class A-1" Air Compressor.

Fig. 2921. Auxiliary Reservoir and Dwarf Signal Foundation Combined.

Fig. 2922. Elevated Railroad Type of Auxiliary Reservoir. The Union Switch & Signal Company.

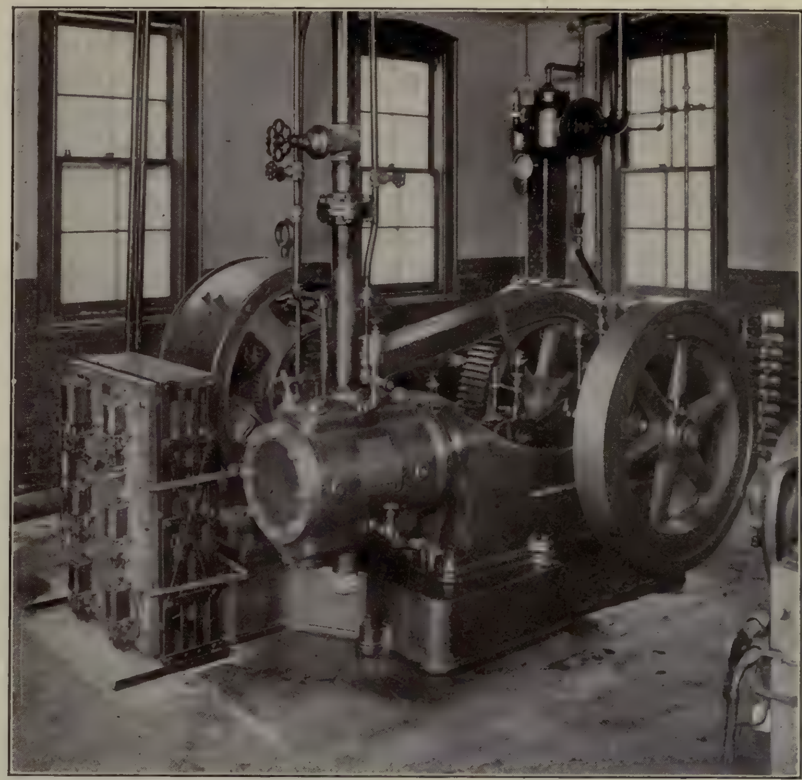


Fig. 2924. Motor-Driven Air Compressors for Electro-Pneumatic Interlocking Plant at East New York. Brooklyn Rapid Transit Company. The Union Switch & Signal Company.

Fig. 2925. Hose Connection with Union. The Union Switch & Signal Company.

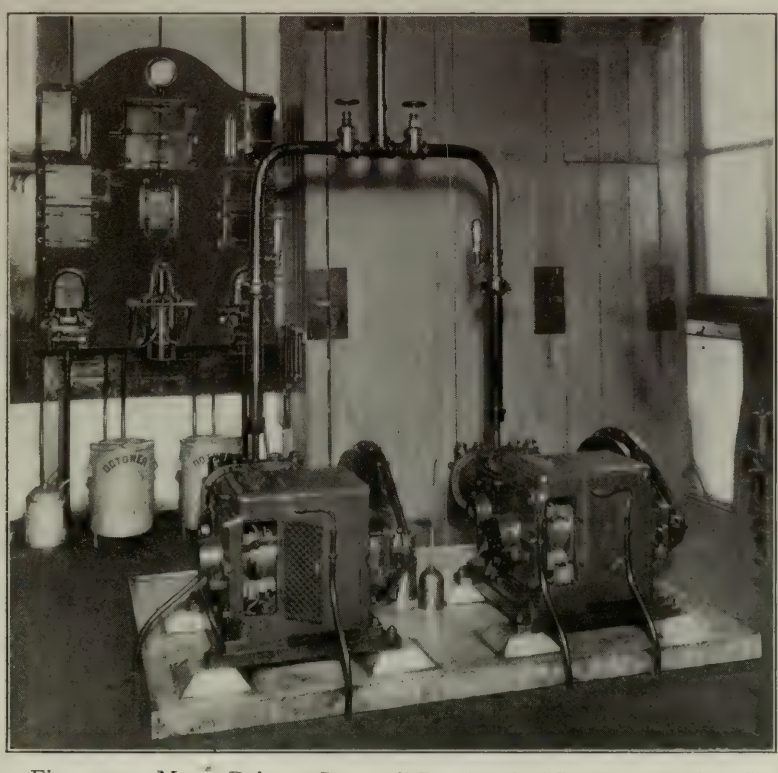
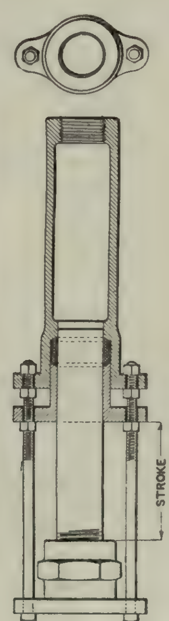


Fig. 2923. Motor-Driven Ingersoll-Rand Air Compressor for Electro-Pneumatic Interlocking Plant at St. George. Baltimore & Ohio. The Union Switch & Signal Company.



Figs. 2926-2927. Expansion Joint for Air Pipe. The Union Switch & Signal Company.

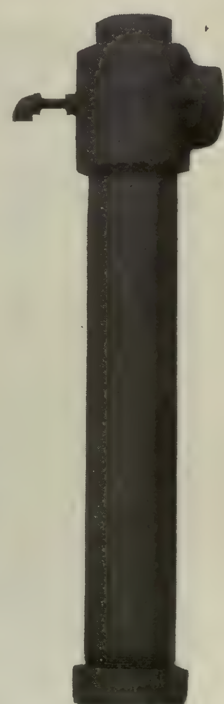
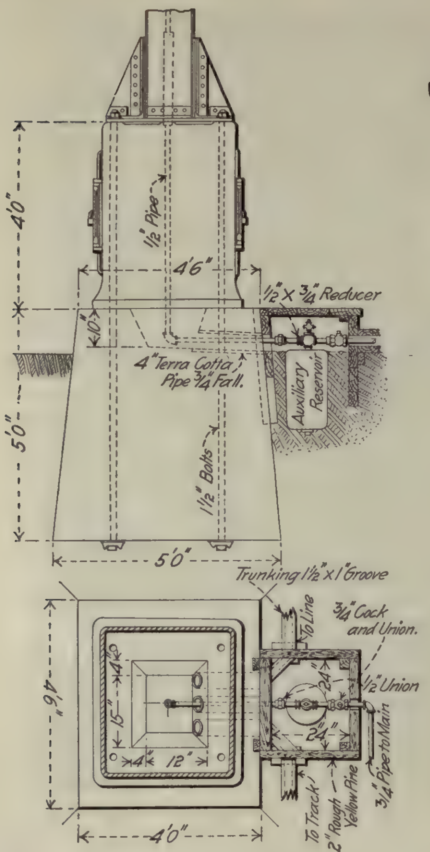


Fig. 2928. Auxiliary Reservoir. The Union Switch & Signal Company.



Figs. 2929-2930. Method of Supplying Air to Electro-Pneumatic Signals on Bracket Post. Pennsylvania Railroad.

Fig. 2931. Air Compressor Governor. General Electric Company

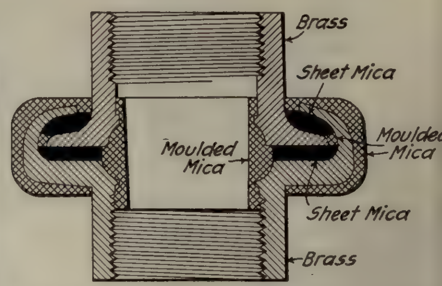


Fig. 2932. Pipe Insulation. H. W. Johns-Manville Company.

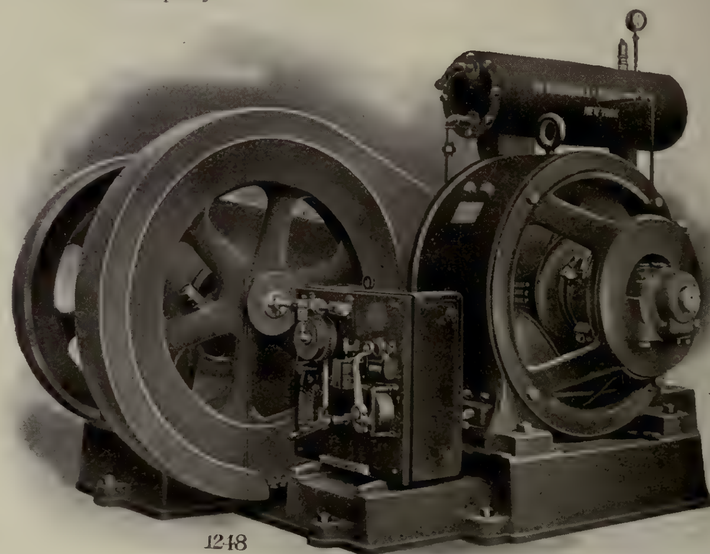


Fig. 2933. Ingersoll-Sergeant Motor-Driven Air Compressor. Interborough Rapid Transit Company.

Fig. 2934. Motor-Driven Air Compressors and Control Switchboards for Electro-Pneumatic Interlocking Plant. Baltimore & Ohio. The Union Switch & Signal Company.

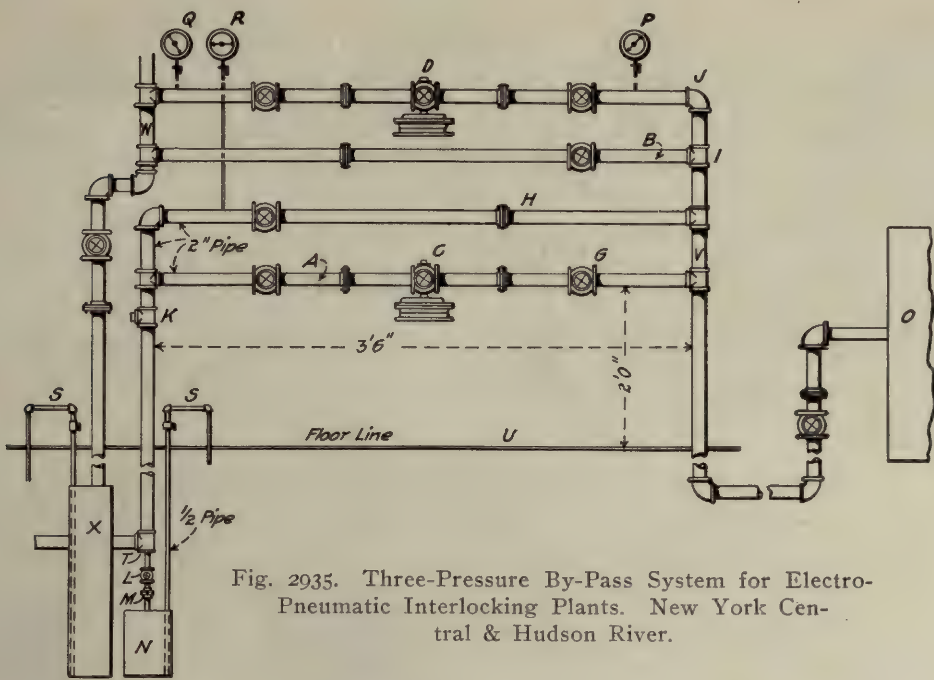


Fig. 2935. Three-Pressure By-Pass System for Electro-Pneumatic Interlocking Plants. New York Central & Hudson River.

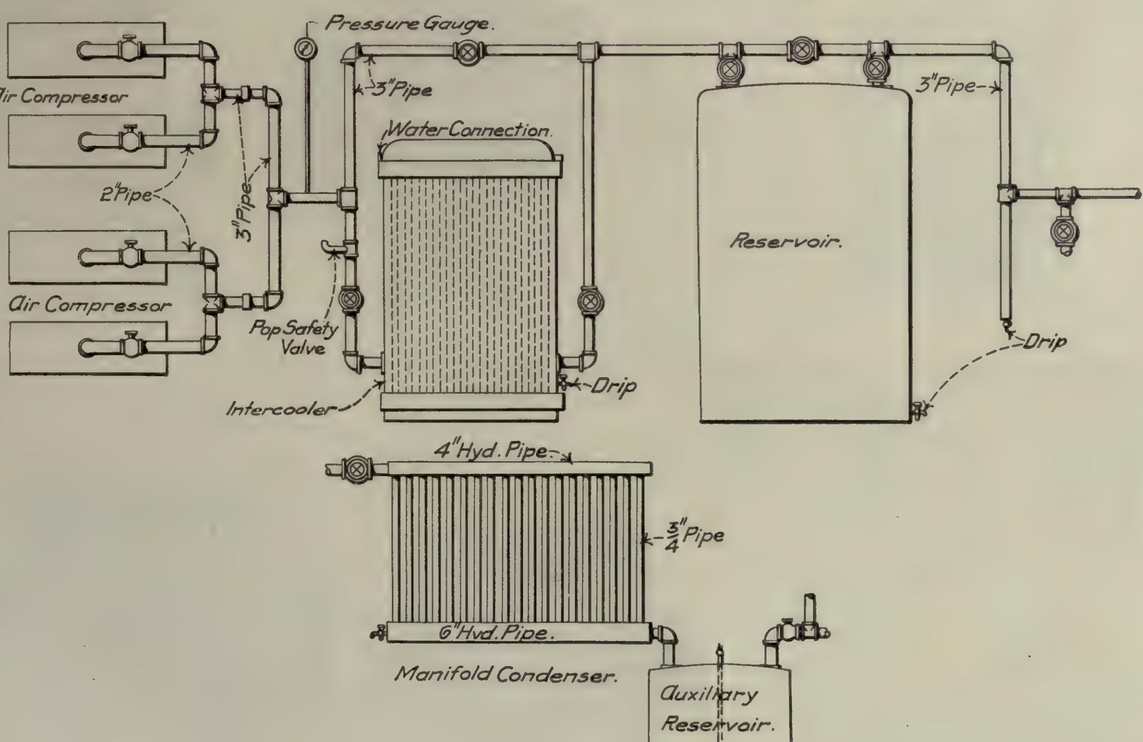


Fig. 2936. Standard Connections to Air Compressors, Water Cooler, Air Reservoir, Cooling Coils and Auxiliary Reservoir for Electro-Pneumatic Interlocking Plant. New York Central & Hudson River.

Names of Parts for Three-Pressure By-Path System; Fig. 2935.

A *High Pressure Line*
B *Intermediate Pressure*
C *High Pressure Foster Reducing Valve*
D *Low Pressure Foster Reducing Valve*
E *H. P. By-Path*
F *L. P. By-Path*
G 2" *Globe Valves*
H 2" *Flange Unions*
I 2" *T's*
J 2" *L's*
K 2" x 2" x ¾" *T's for Hose Connections*
L 1" *Globe Valve*
M 1" *Union*
N *Drip Tank or Reservoir*
O *Intermediate Pressure Storage Tank*
P *I. P. Gauge*
Q *L. P. Gauge*
R *H. P. Gauge*
S *Siphon Pipe*
T 2" x 1" x 2" *T*
U *Floor Line*
V 2" x 6" *Nipples*
W 2" x 7½" *Nipples*
X *L. P. Storage Tank*

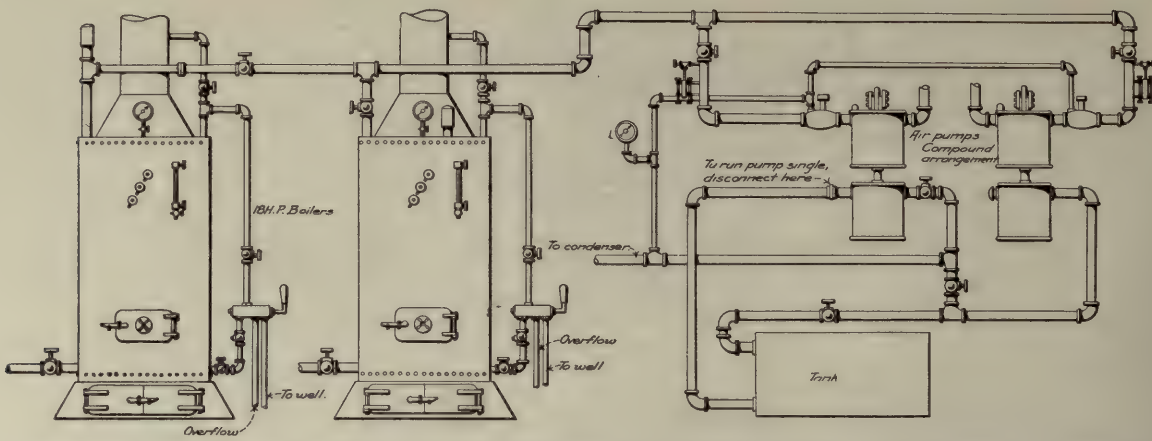


Fig. 2937. Air Compressor Plant Using Air Brake Apparatus. New York, Ontario & Western.

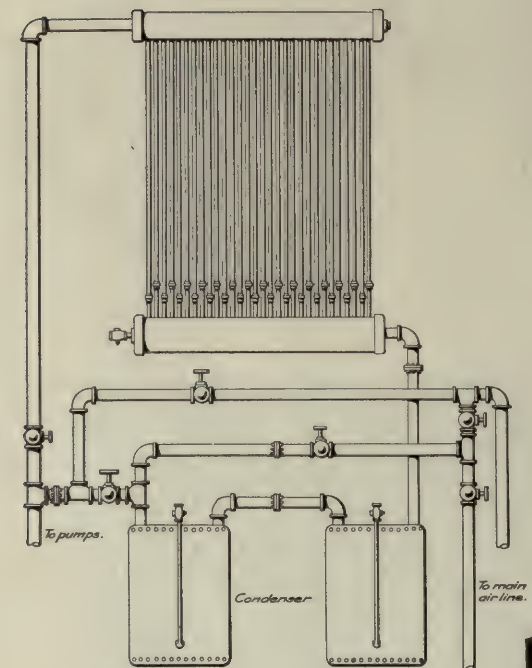


Fig. 2938. Cooling Coils and Drip Tanks for Electro-Pneumatic Interlocking Plant. New York, Ontario & Western.

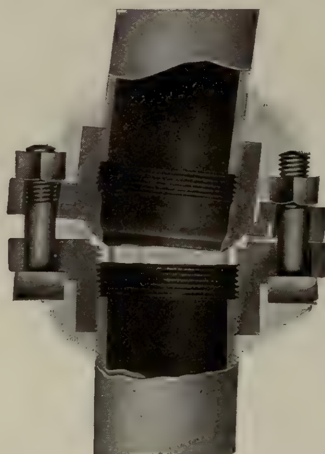


Fig. 2939. "Kewanee" Brass and Malleable Iron Self-Seating Ball Joint Flange Union. National Tube Company.

Fig. 2940.

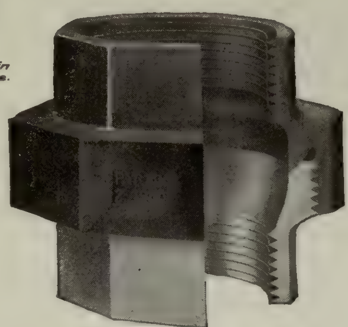


Fig. 2941.

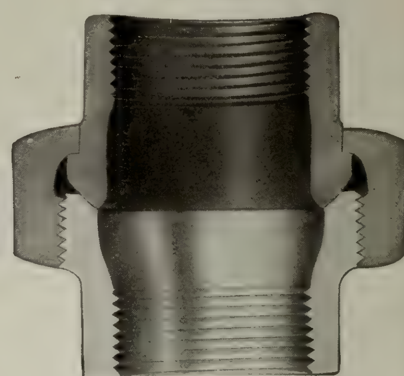


Fig. 2942.

Figs. 2940-2942. Pipe Unions with Ground Brass Seats. National Tube Company.

POWER SUPPLY CIRCUITS

NEW YORK, ONTARIO & WESTERN.

Fig. 2943 is a diagram of circuits and apparatus for supplying electric power to the electro-pneumatic interlocking plant at Fallsburgh Tunnel, on the New York, Ontario & Western, where double track converges into single track through the tunnel and one plant controls the switches and signals at both ends. Current is normally furnished by one of the air-driven generators, supplied with air from the switch and signal mains. One generator is held in reserve and a primary battery is also installed of sufficient capacity to operate the plant should both generators break down at the same time. Indicator A is controlled by a track circuit through the tunnel. It has a stick wiring (not shown) so arranged that after the train enters the section with a clear signal, the indicator cannot pick up until the train has left the section and the signal has been restored to the normal position. As shown the indicator breaks all signal control circuits. The relay B is also controlled by the indicator, and in turn controls lock circuits for the units.

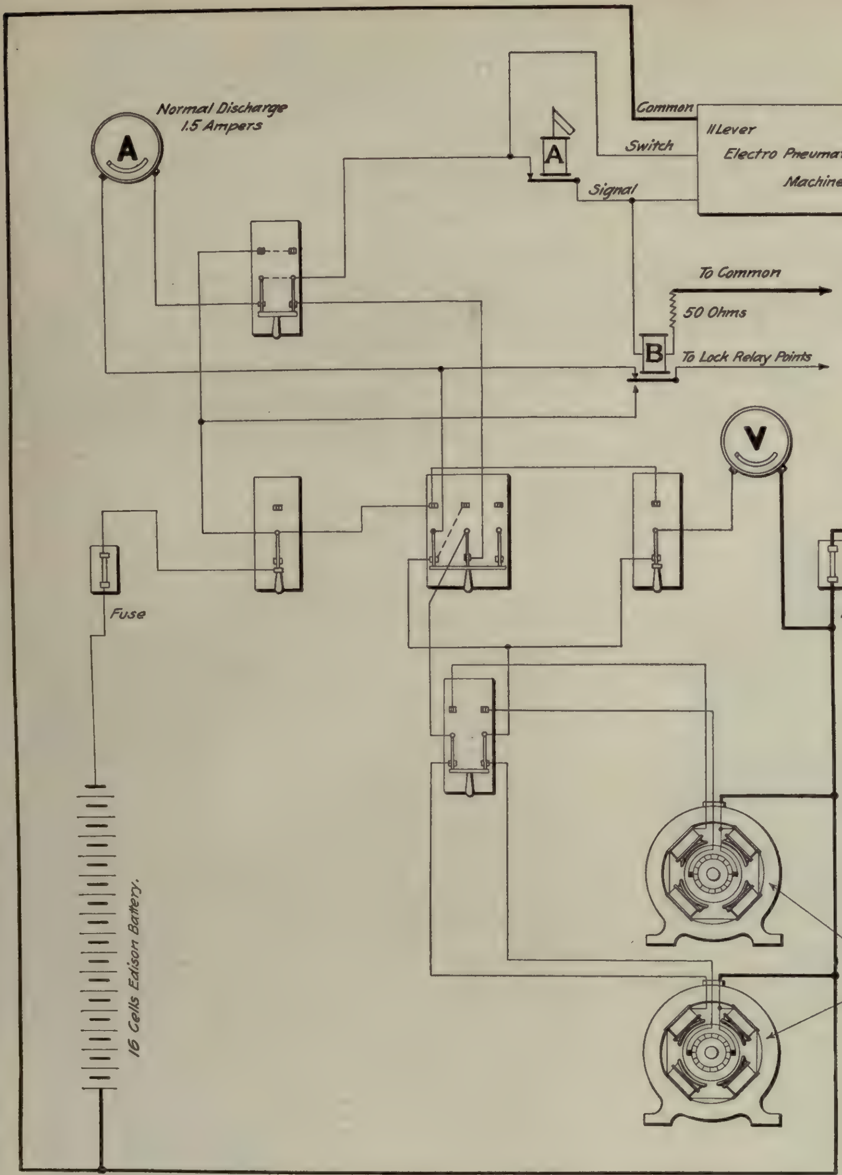
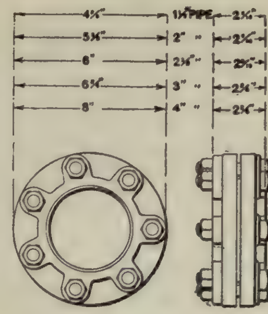
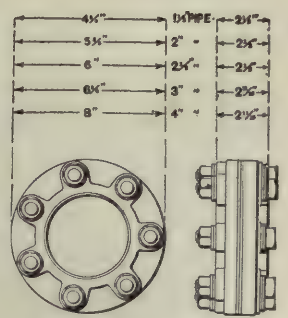


Fig. 2943. Circuits for Power Supply, Electro-Pneumatic Interlocking Plant. New York, Ontario & Western.



Figs. 2944-2945. Flange Union.



Figs. 2946-2947. Insulated Flange Union.

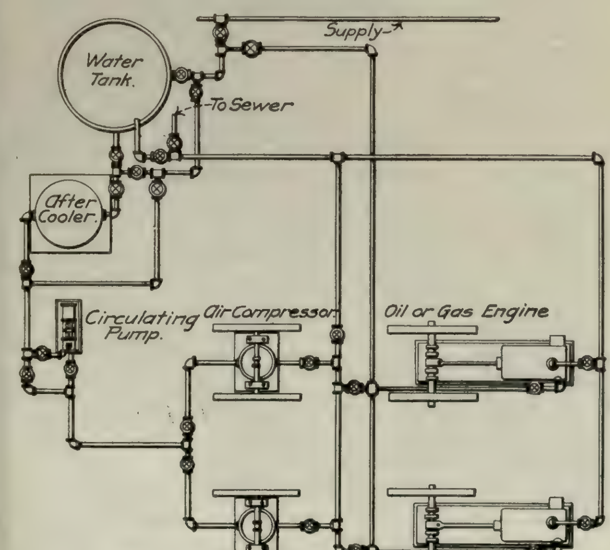


Fig. 2948. Standard Piping and Water Cooling Connections for Air Compressor Plants.

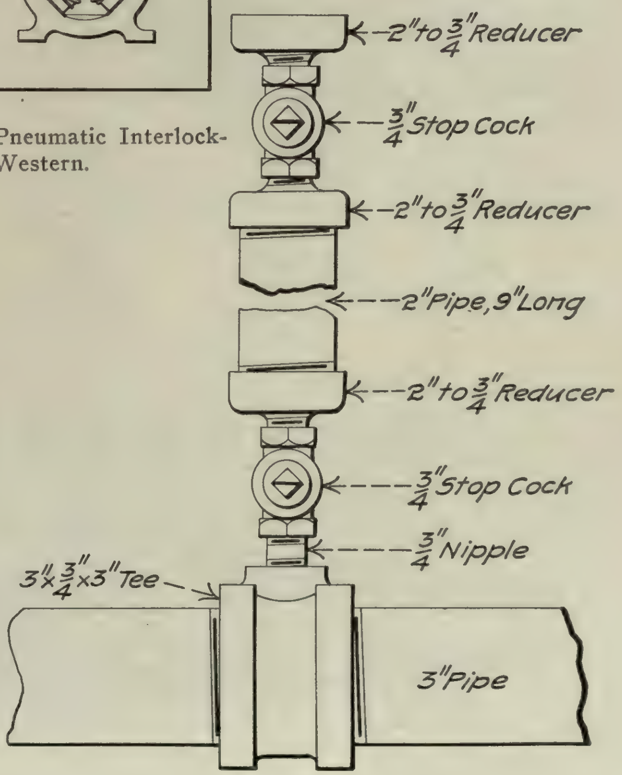


Fig. 2949. Alcohol Inlet Valve for Air Pipe. New York Central & Hudson River.

BATTERY CHARGING SWITCHES

GENERAL ELECTRIC BATTERY CHARGING SWITCH.

In the battery charging switch manufactured by the General Electric Co. the charging line is connected to each side of the two-pole switch, and the duplicate sets of batteries, which are charged alternately, and the signals or other apparatus to be operated are connected to the four-pole switch. By the interlocking device contained in the handle it is impossible to reverse the four-pole switch without throwing in a resistance in the line with the two-pole switch. This resistance is mounted in fuse clips and can be easily removed.

HALL BATTERY CHARGING SWITCH.

The charging switch shown in Fig. 2963 consists of a base of asbestos wood, upon which is mounted a central shaft provided with a suitable hand crank. Rigidly fastened to the shaft are a number of contact segments. These segments are insulated from the shaft, and from each other. When the shaft is partially revolved the segments engage with or are withdrawn from certain of the contact jaws, thus opening or closing the

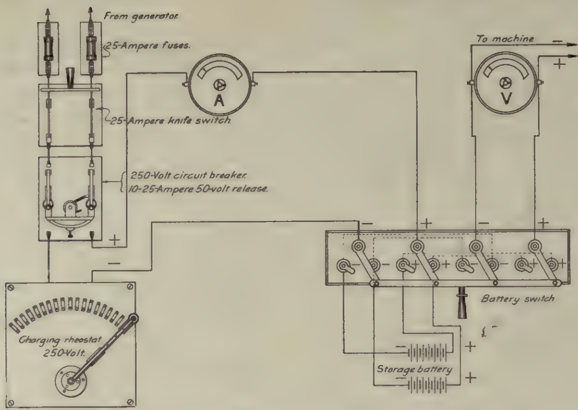


Fig. 2950. Battery Charging Circuit. New York, Ontario & Western.

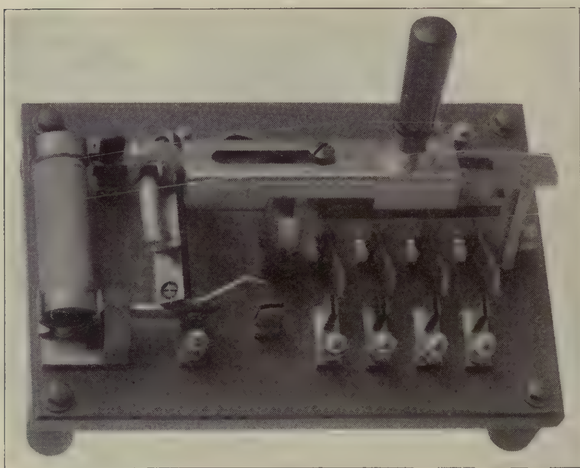
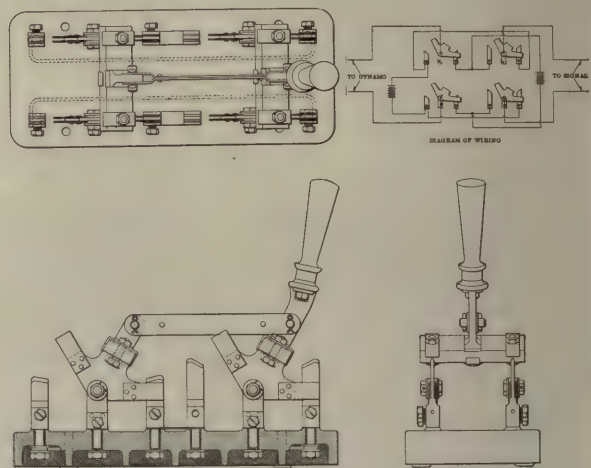
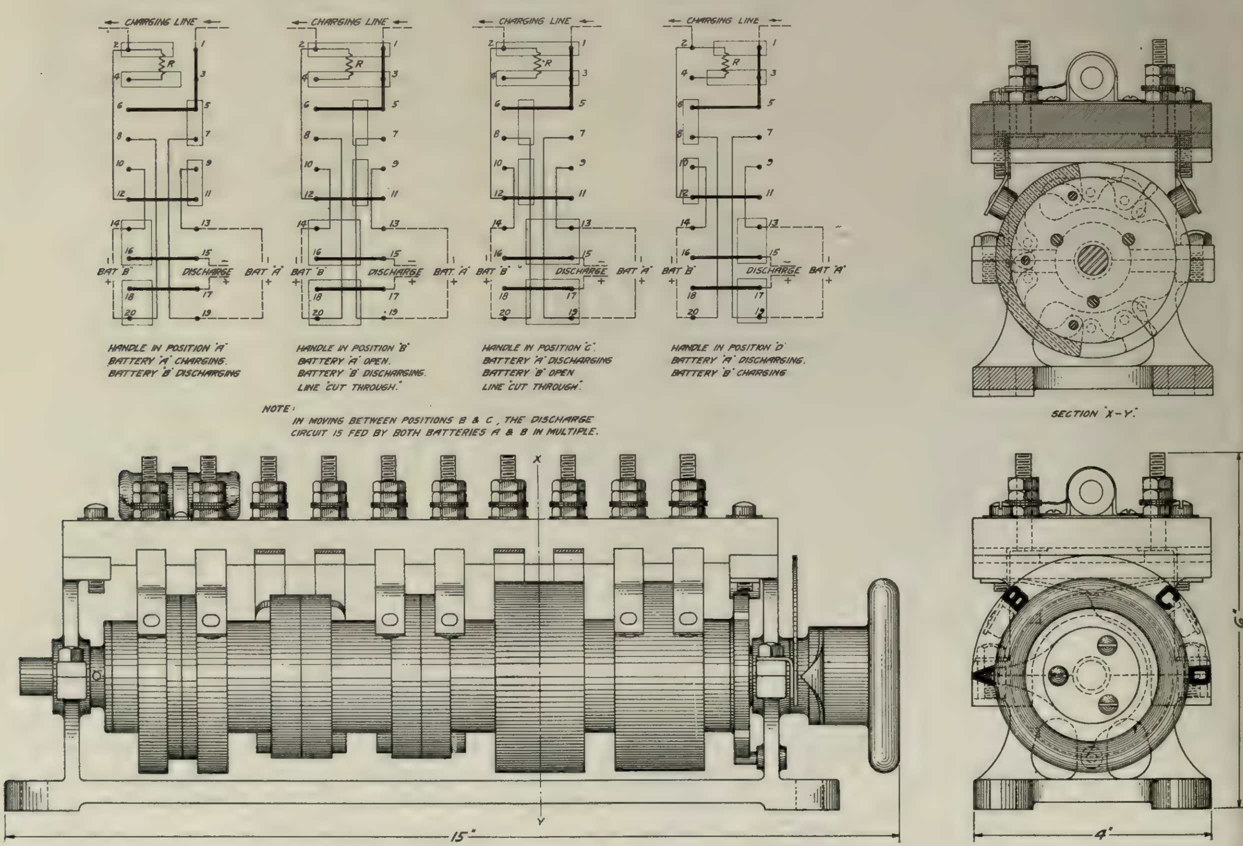


Fig. 2951. Interlocking Type Battery Charging Switch for Railway Signals. General Electric Company.



Figs. 2952-2955. Four-Pole Double Throw Knife Circuit Controller (Battery Charging Switch). The Union Switch & Signal Company.



Figs. 2956-2962. Battery Charging Switch and Operating Circuits. Federal Signal Company.

desired circuits. The hand crank of this switch is provided with a latch having a spring plunger, which automatically locks the switch in either extreme position or one of two intermediate positions. Fig. 2964 shows a number of the Hall Signal Company's battery charging switches as installed on the New York Central.

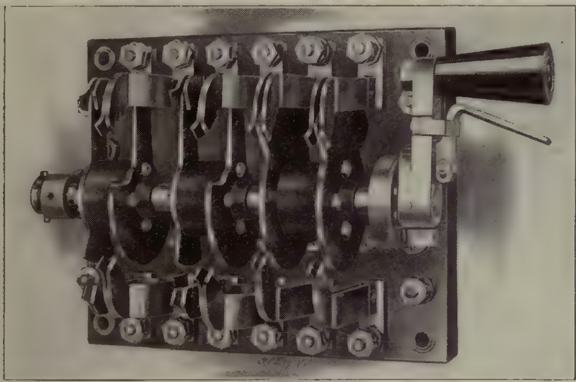


Fig. 2963. Battery Charging Switch. Hall Signal Company.

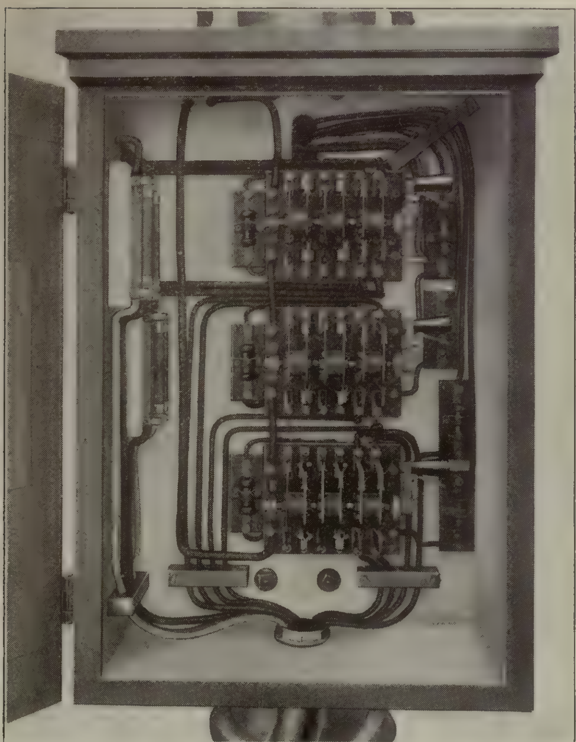


Fig. 2964. Charging Switches in Box. Hall Signal Company.

G. R. S. BATTERY CHARGING SWITCH.

Fig. 2965 illustrates the General Railway Signal Company's battery charging switch for connecting storage batteries in series with charging and discharging lines.

During the manipulation of the switch the battery is not short-circuited while being connected to the line, nor is the series line interrupted. The design is such that a resistance is automatically inserted during the interval that the battery would otherwise be on short circuit, which resistance is again cut out as soon as the short-circuiting point is passed by the contact.

Manipulation of the switch is simple, the four different positions of the switch controlling the batteries being as shown in the following table:

1—Battery A discharging; battery B charging.
2—Battery A discharging; battery B open.
3—Battery B discharging; battery A open.
4—Battery B discharging; battery A charging.

The contact plates and fingers are large and designed to take care of the heavy currents necessary in this kind of service without heating.

Figs. 2966-2969 show the circuits for the battery charging switch, Fig. 2965. Fig. 2966 shows the connections while battery A is discharging and battery B is charging; Fig. 2967 shows the connections while battery A is discharging and battery B is open; Fig. 2968 shows the connections while battery B is discharging and battery A is open; and Fig. 2969 shows the connections with battery B discharging and battery A charging.

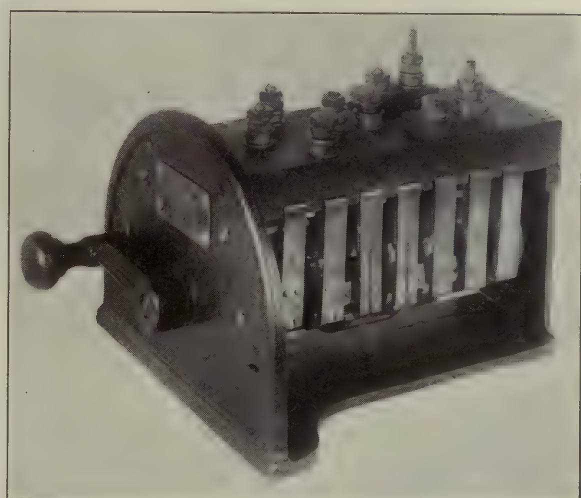
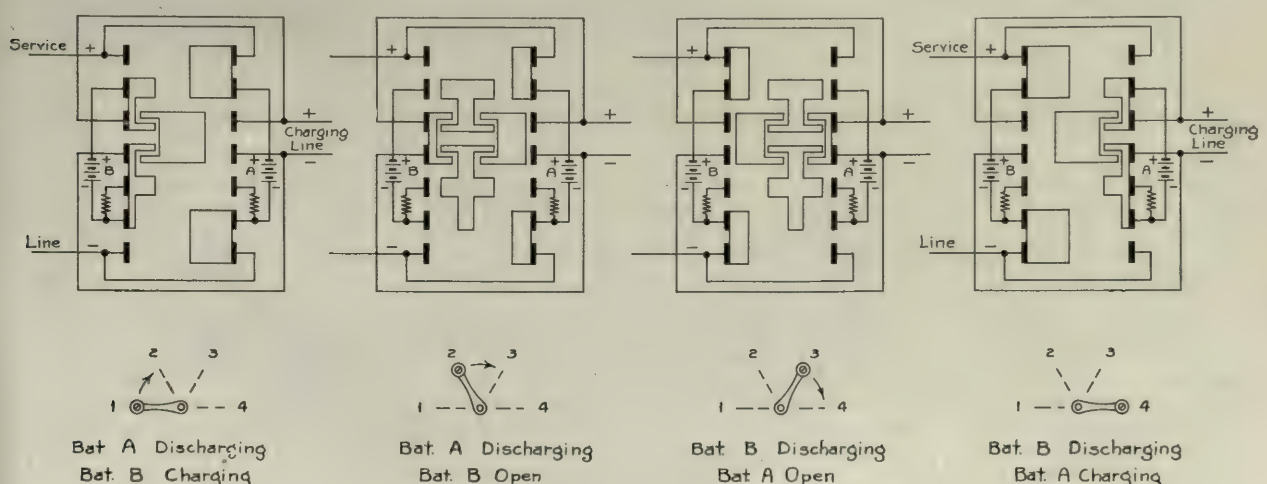


Fig. 2965. Battery Charging Switch. General Railway Signal Company.



Figs. 2966-2969. Circuits for General Railway Signal Company's Battery Charging Switch.

TRANSFORMERS

Fig. 2970. Core and Coils of Type "H" Line Transformer Oil-Cooled. General Electric Company.

Fig. 2971. Secondary Side Type "H" Line Transformer. General Electric Company.

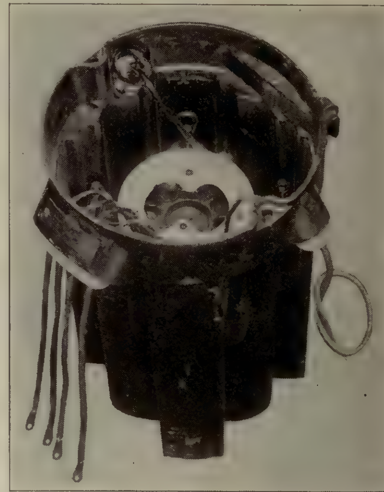


Fig. 2972. Type "H" Form K Line Transformer. General Electric Company.

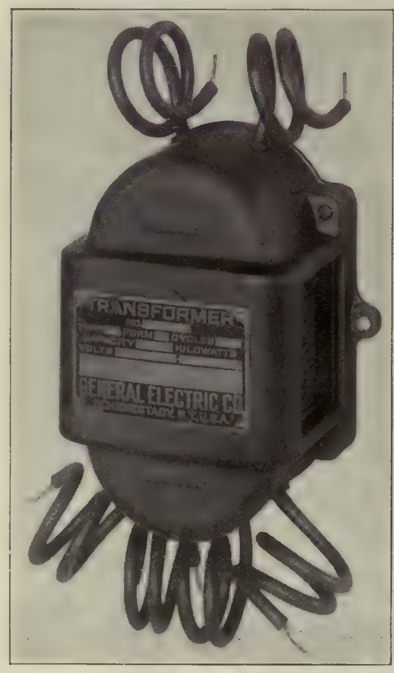


Fig. 2973. Type "N. D." Form 3 Lighting Transformer 110/8-10 Volts. Air Cooled. General Electric Company.

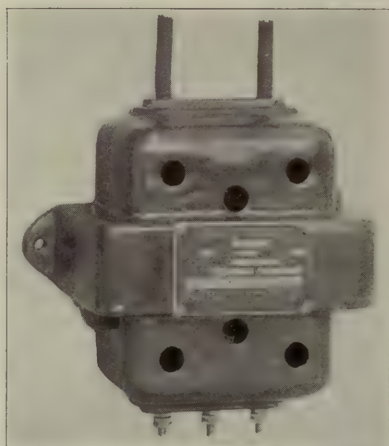
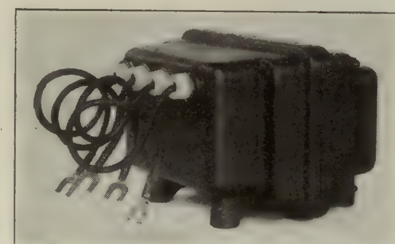


Fig. 2974. Type "N. D." Lighting Transformer 110/10 Volts. General Electric Company.

Fig. 2975. Type "Y" Form "B" Lighting Transformer 110/10 Volts. General Electric Company.



Figs. 2976-2977. Relay Transformer. General Railway Signal Company.

G. R. S. SIGNAL TRANSFORMERS.

The G. R. S. Co.'s Type H. transformer, Figs. 2970-2972, is for use at signal and track feed locations. It is designed to step down directly from the transmission line voltages to those required for the operation of the signal system. These transformers are made in various sizes, as required, and may be provided with any reasonable number of independent secondary coils, each terminating in binding posts located within the transformer, thus doing away with a number of external leads which may or may not be required.

REACTANCES AND RESISTANCE UNITS

UNION REACTANCE COIL FOR ELECTRIC ROAD TRACK CIRCUITS.

This coil is designed for connection between the transformer and track in electric road track circuits of the double rail system with impedance bonds. On account of the larger current values encountered in this system, much heavier copper and fewer turns are required.

Suitable terminals are provided for connecting directly to the coil winding, and no taps provided. Adjustment of the impedance of the coil is secured by varying the air gap in the magnetic circuit, which is accomplished by loosening the supporting clamps and raising or lowering the upper half of the core. Fibre spacers of the proper thickness determine the air gap. By this means the impedance may be varied from 0.1 to 1.25 ohms, 25 cycles.

The coil is impregnated by the vacuum process and thoroughly weather-proof. The capacity of this type of reactance coil is 10 volts, 60 amperes, 25 cycles, and the power factor about 10 per cent.

UNION REACTANCE COIL FOR STEAM ROAD TRACK CIRCUITS.

The coil shown in Figs. 2979-2980 is designed for connection between the transformer and track in steam road alternating current track circuits, and limits the flow of current from the transformer when the track circuit is shunted by a train. It consists of a single coil with uniformly graded taps brought out to terminal posts, the coil being enclosed in a laminated magnetic circuit containing an adjustable air gap. A suitable wooden base provides a convenient means for mounting in the back of the relay compartment. The number of taps provide

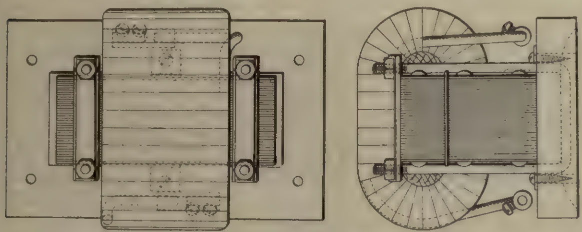


Fig. 2978. Single Winding Reactance Coil. The Union Switch & Signal Company.

sufficient variation in impedance to take care of ordinary adjustments, and a greater range may be obtained by varying the air gap in the magnetic circuit.

As the coil has an extremely low power factor, the watt energy consumed is extremely small, resulting in a considerable saving in power, the saving over that required were a resistance used for the same purpose usually being from 30 per cent to 50 per cent of the total power supplied to the track circuit, an amount sufficient at the usual costs for power to pay in a short time for the difference in cost between the reactance coil and a resistance tube.

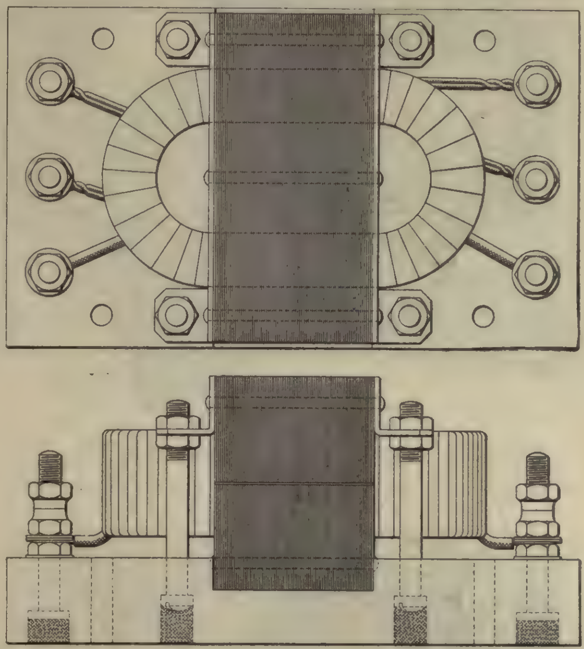
The coil is designed for operation on either 25 or 60 cycles, and has a maximum capacity of 30 volts, 15 amperes.

UNION IMPEDANCE BOND.

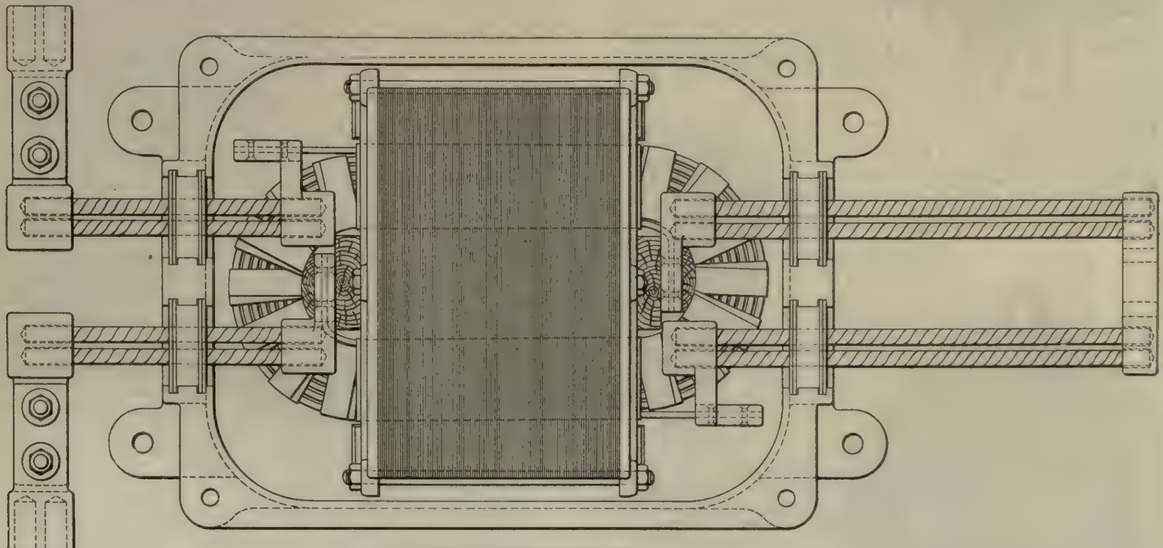
The type of impedance bond shown in Figs. 2981-2982 represents a considerable advance in construction over types previously in use. The winding consists of a nine-turn coil of copper strap in two sections of four and one-half turns each, wound in a spiral with edges vertical. Ducts are provided between the successive turns to secure ample oil circulation. Means are provided for readily varying the air gap in the magnetic circuit at any time should special track conditions demand it. In order to secure a maximum degree of flexibility the terminals are made of four 350,000 c. m. standard cables.

The bond may be filled with either transformer oil or petrolatum. When the latter is used, the bonds are filled and sealed ready for installation before they leave the factory. This considerably decreases the labor of installation and minimizes the possibility of defective sealing and the consequent admission of water.

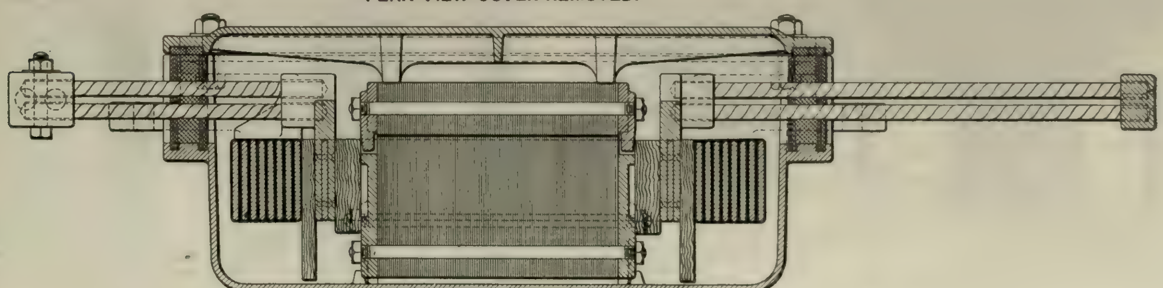
This bond is rated at 1,500 amperes per rail continuous capacity, or 2,000 amperes per rail for one hour, and may be adjusted to have a variation of less than 10 per cent in impedance with an unbalancing of 800 amperes.



Figs. 2979-2980. Reactance Coil for Steam Road Track Circuits. The Union Switch & Signal Company.



PLAN VIEW-COVER REMOVED.



SECTIONAL SIDE VIEW.

Figs. 2981-2982. Impedance Bond with Spiral Wound Coil. The Union Switch & Signal Company.

Figs. 2983-2984. Sectionalizing Panel With Transformer Housing. General Electric Company.

G. R. S. AUTOMATIC REACTANCE.

Fig. 2989 illustrates the automatic reactance manufactured by the General Railway Signal Company. The device, which is used in A. C. signaling, is inserted in one of the track transformer leads to the rail, to limit the current fed to the track circuit when a train is present. Its use is of particular advantage where the energy taken by the track circuit is large. The automatic reactance, thus installed, takes the place of the ordinary resistance or fixed reactance employed for that purpose. When the track circuit is unoccupied, the automatic reactance presents practically no resistance to the passage of the current to the rails, but with the train present, limits the current to a predetermined amount much less than is the case with the ordinary resistance or reactance. Furthermore, it affords broken down joint protection, the design being such that should the track insulation break down, the current which would thereby be fed to the relay of the adjacent section, will have practically the same phase displacement as the current flowing in the local of that relay and thus will not cause its false operation. The automatic reactance has no moving wires or contacts. Its size and the fact that it does not become heated, permit it to be installed in ordinary relay boxes.

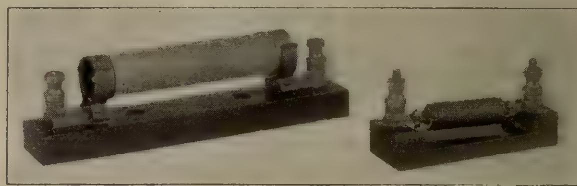


Fig. 2987. Mounted Resistance Units for Railway Signals. General Electric Company.

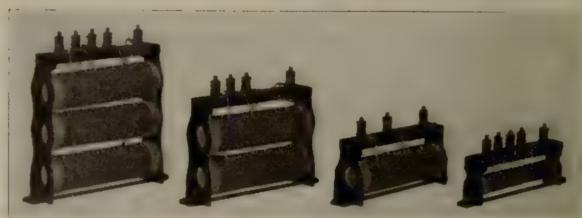


Fig. 2988. Type "SU" Resistance Units. General Electric Company.

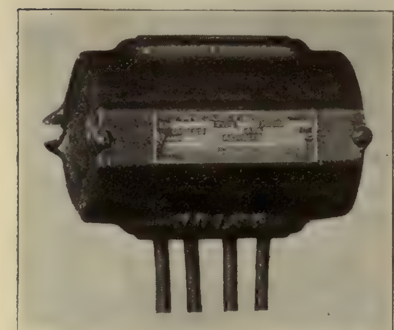


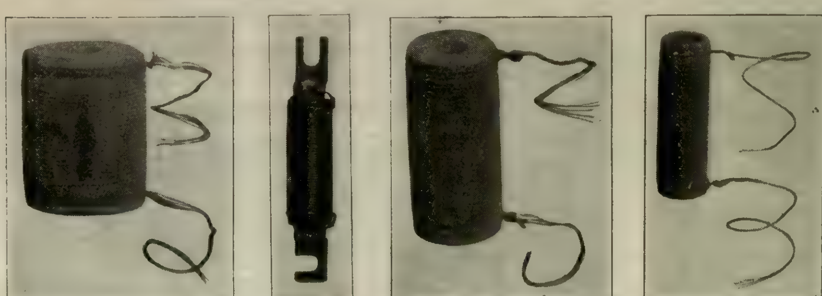
Fig. 2985. Type "NS" Form "D" Reactance. General Electric Company.

Fig. 2989. Automatic Reactance. General Railway Signal Company.

GENERAL ELECTRIC RESISTANCE UNITS.

The General Electric Company's type SU resistance units are used principally for track circuit work, to prevent short circuit when the track is occupied, and to afford a suitable means for voltage regulation. The frame consists of cast iron supports with a sheet iron connection on the bottom and a wooden top plate which contains the terminals.

Fig. 2986. Type "R. S." Form I Reactance. General Electric Company.



Figs. 2990-2993. Miscellaneous Group of Resistance Units. General Electric Company.

SWITCHES AND CIRCUIT BREAKERS

GENERAL ELECTRIC OIL BREAK SWITCH.

The oil break switch is adapted particularly for use on alternating current. It can be used simply as a switch to open or close the circuit by hand or when equipped with automatic features will give automatic protection against the effects of predetermined abnormal conditions. The switch interrupts an electrical circuit in oil without producing abnormal disturbances in that circuit. It confines the destructive arc to a small volume, thereby preventing its spread to adjacent apparatus and can therefore be safely placed in any convenient location on the switchboard or in the power station.

When the switch is opened the alternating current, which tends to maintain an arc in the oil, is interrupted when the current passes through zero (at which point the electro-magnetic energy is a minimum), which enables the oil break switch to interrupt the circuit with very little disturbance and with no appreciable surge on the line.

GENERAL ELECTRIC CIRCUIT BREAKER.

The function of a circuit breaker is automatically to protect electrical apparatus from undesirable effects arising from abnormal conditions, such as overload or short circuit, underload, low voltage, over voltage, reverse current, reverse phase or combinations of these conditions. It is a very flexible piece of apparatus and can be used to act instantaneously, after a predetermined time limit, or in a certain sequence.


Fig. 2994. Type "C" Form "P" Double Pole Circuit Breaker, General Electric Company.

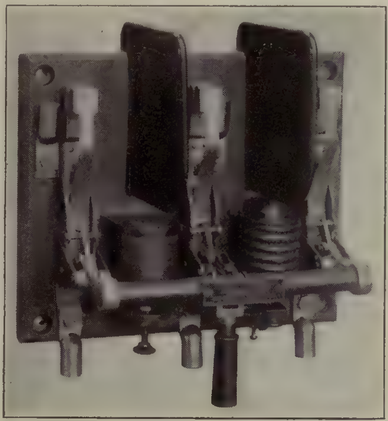


Fig. 2995. Type "C" Form "G" Circuit Breaker With One Overload and One Low Voltage Coil.

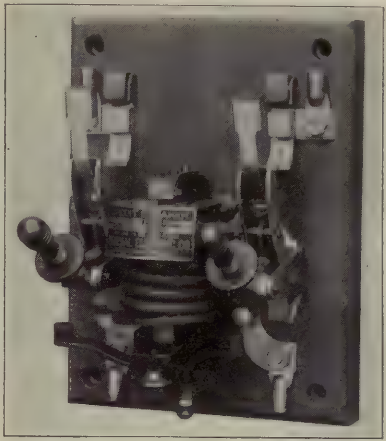


Fig. 2996. Type "C" Form "G" Circuit Breaker, Front Connected.

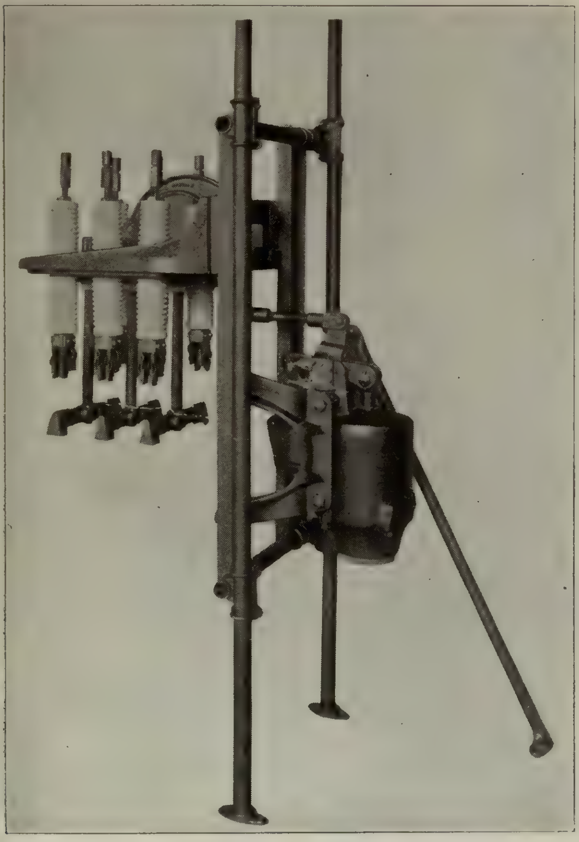


Fig. 2997. Type "K-12" Oil Switch, Solenoid Operated, on Pipe Framework.

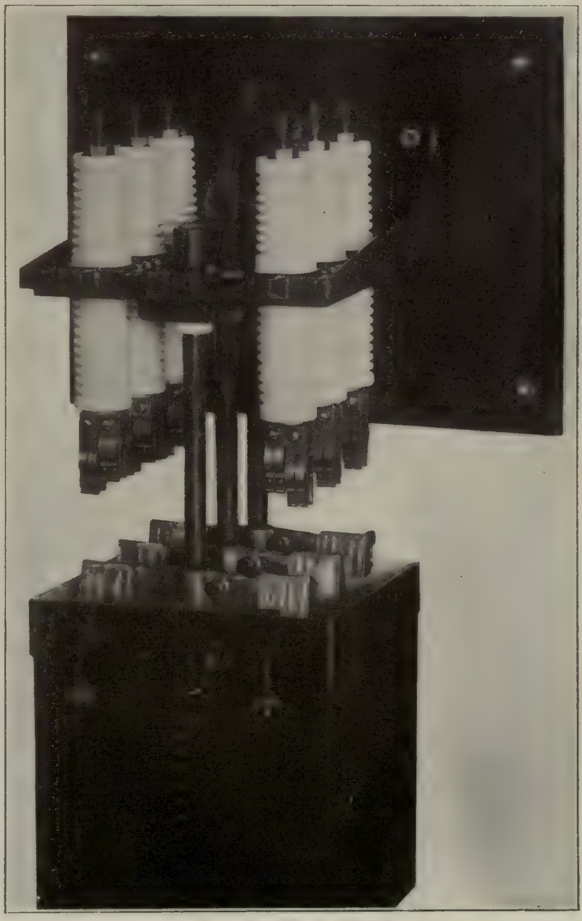


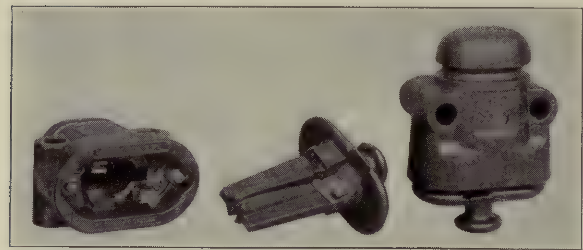
Fig. 2998. "K-12" Oil Switch With Oil Vessel Lowered, Showing Contacts.

The automatic operation of a circuit breaker is usually accomplished by an electro-magnet, the current coil of which is connected in series with the circuit and carries all the current flowing through that circuit. The power of the electro-magnet depends on the amount of this current and not on the voltage.

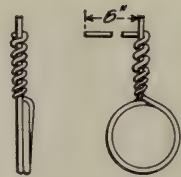
A potential coil is connected across the line and carries only that fraction of the total current that the voltage of the system can force through its high resistance winding and series resistance. The power of this electro-magnet depends upon the potential of the system, and not in any way upon the amount of current flowing in that system.

Overload and underload protection is secured by the use of current coils. Low voltage and shunt trip attachments are actuated by potential coils.

WIRING AND DETAILS.



Figs. 2999-3001. Primary Cut Outs. General Electric Company.



Figs. 3003-3004. Line Wire Dead End. Chicago & North-Western.

Fig. 3007. High Tension Pole and Line. New York Central & Hudson River.

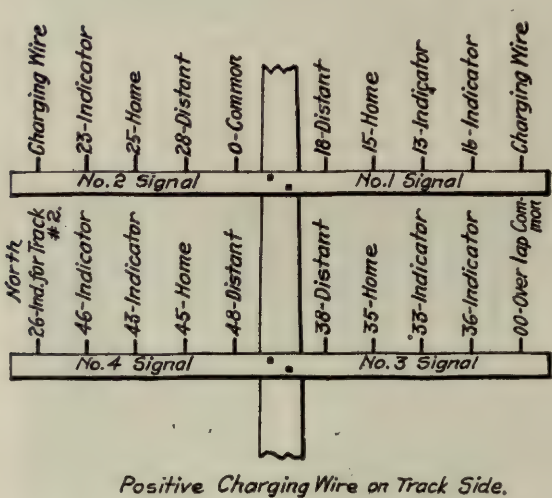
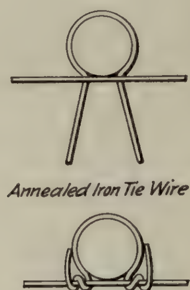
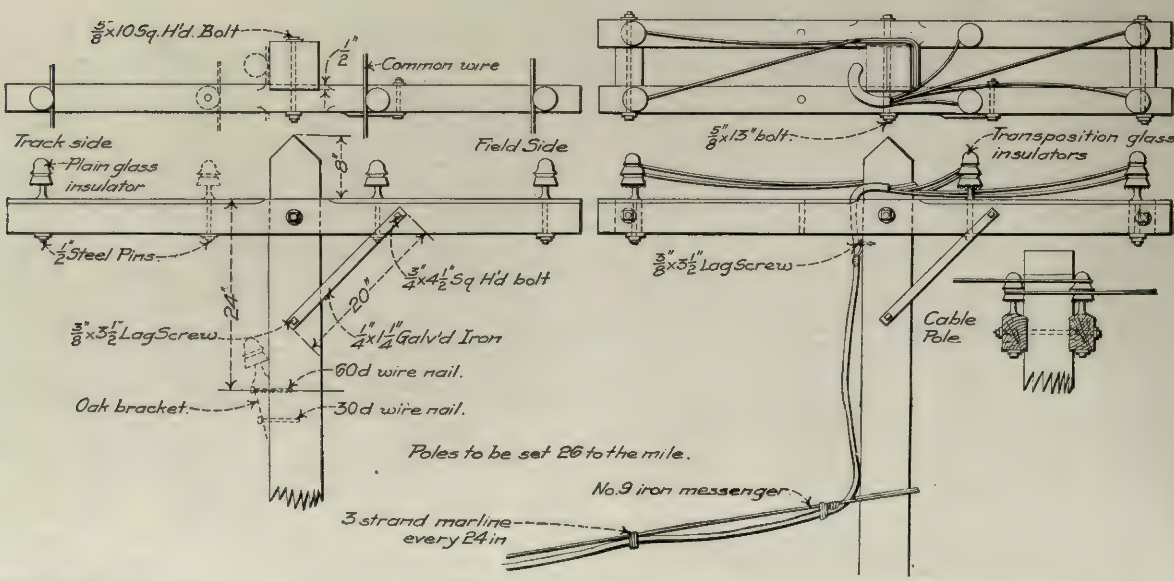


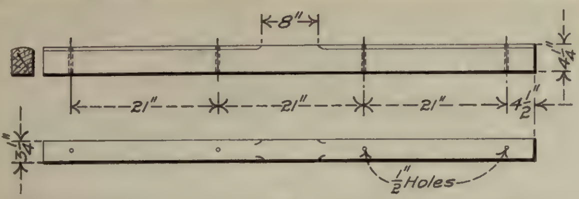
Fig. 3002. Standard Arrangement of Line Wires for Automatic Block Signals. Lake Shore & Michigan Southern.



Figs. 3005-3006. Method of Tying Iron Line Wire to Insulator. Chicago & North-Western.



Figs. 3008-3012. Details of Pole Construction and Wiring. Southern Pacific-Union Pacific.



Figs. 3013-3014. Standard Four-Pin Cross Arm, Southern Pacific-Union Pacific.

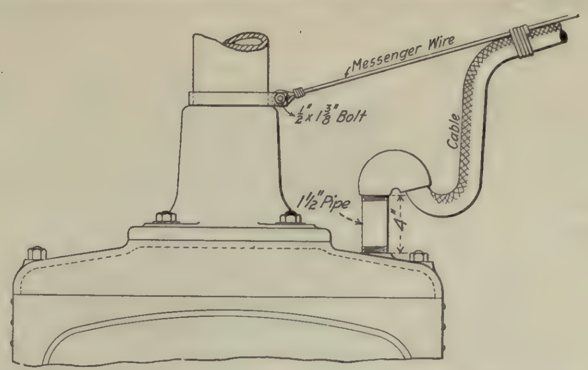
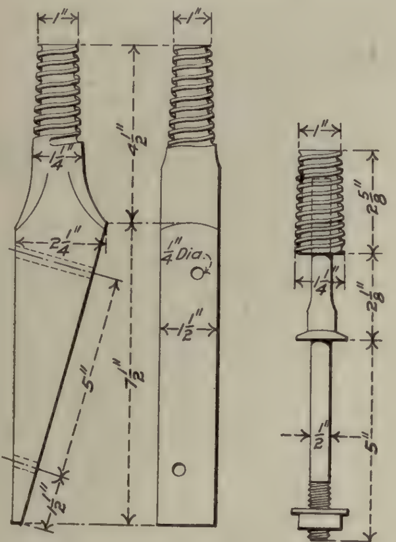
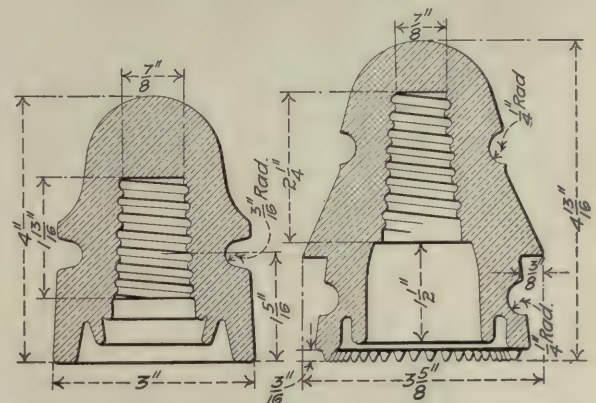


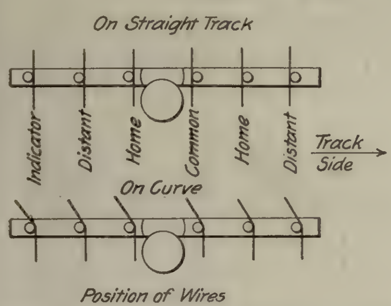
Fig. 3015. Method of Bringing Cable into Mechanism Case. Union Pacific.



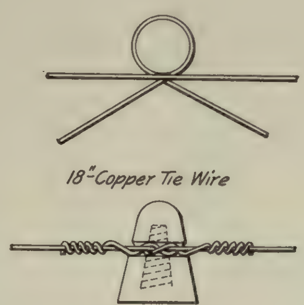
Figs. 3016-3018. Iron Pole Pin and Wooden Bracket. Southern Pacific.



Figs. 3019-3020. Standard Glass Insulators. Southern Pacific-Union Pacific.



Figs. 3021-3022. Location of Signal Wires on Poles. Chicago & North-Western.



Figs. 3023-3024. Method of Tying Copper Line Wire to Insulator. Chicago & North-Western.

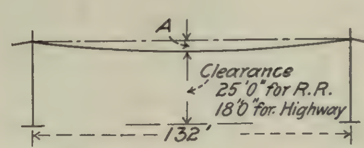


Fig. 3025. Standard Clearance for Line Wire. Chicago & North-Western.

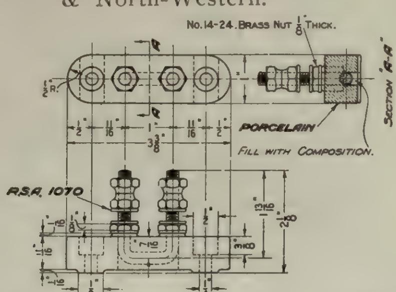


Fig. 3026. R. S. A. Standard Terminal Block.

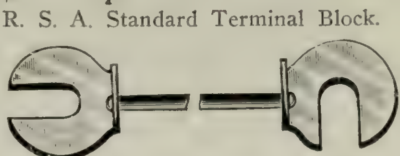
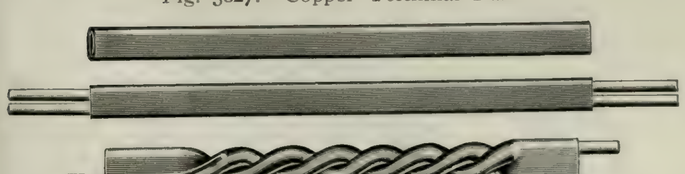
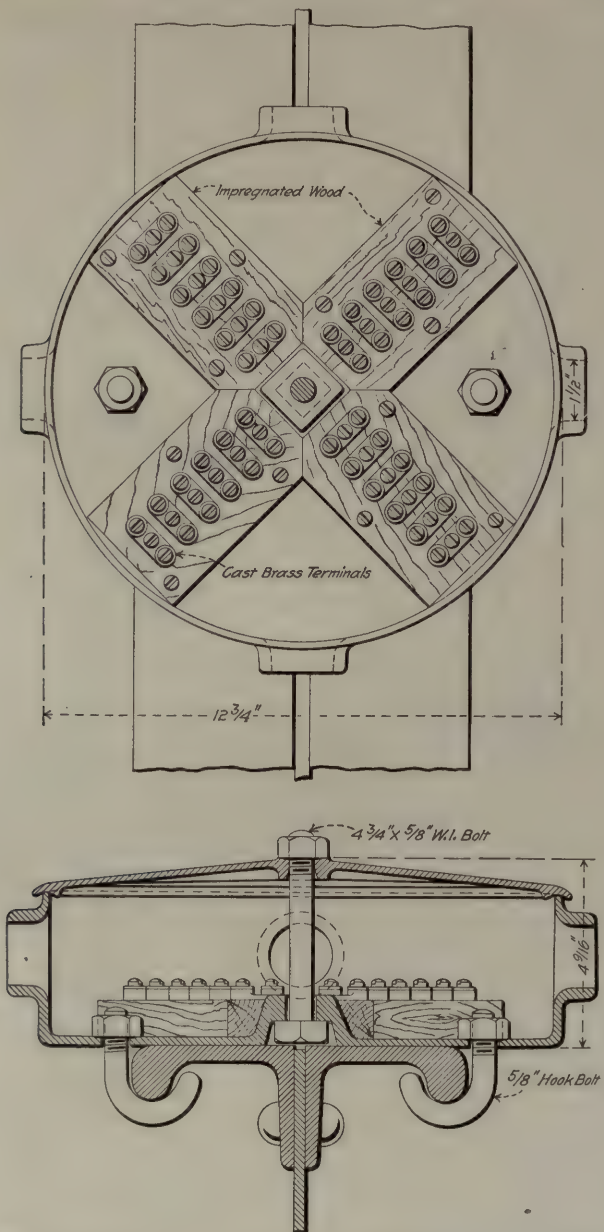


Fig. 3027. Copper Terminal Fuse.

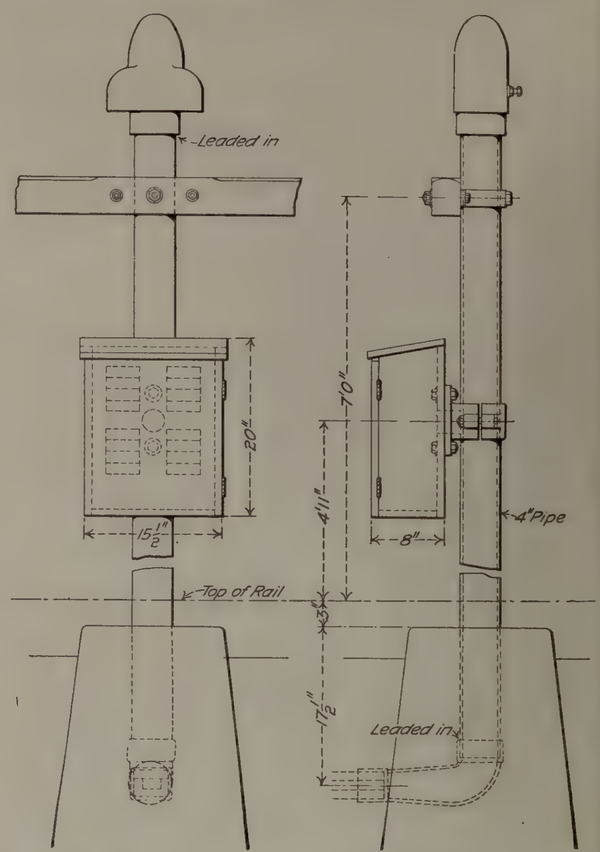


Figs. 3028-3030. Premier Seamless Sleeve. Bryant Zinc Company.

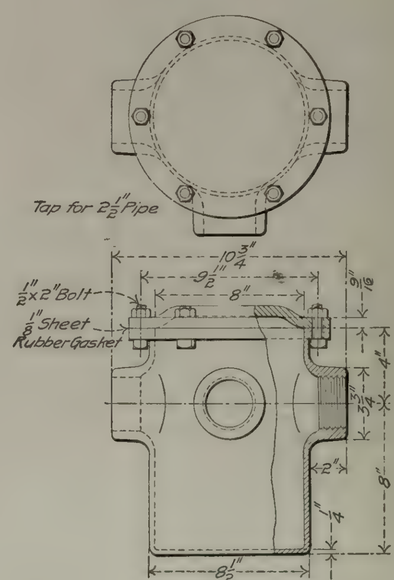
Figs. 3031-3034. Wire Terminals. Bryant Zinc Company.



Figs. 3035-3036. Junction Box Attached to Pillar. Interborough Rapid Transit Company. The Union Switch & Signal Company.



Figs. 3037-3038. Junction Box on Iron Cable Post, with Cross Arm. Lake Shore & Michigan Southern. The Union Switch & Signal Company.



Figs. 3039-3040. Iron Junction Box. Michigan Central.

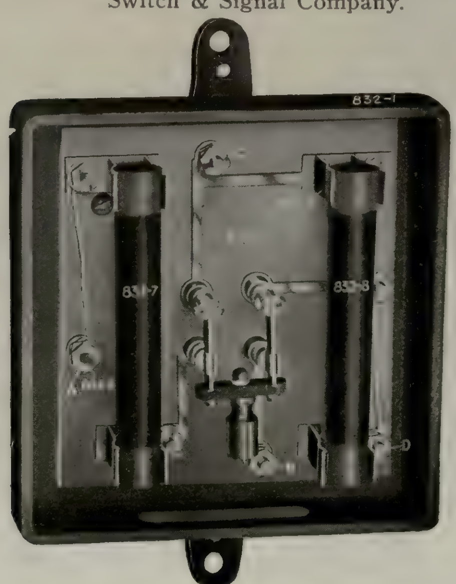
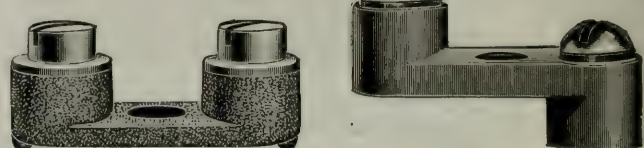


Fig. 3041. Fuse and Junction Box. Railroad Supply Company.



Figs. 3042-3043. Junction Strips.

RELAYS

UNION 9C NEUTRAL TYPE RELAY.

This relay is manufactured by the Union Switch & Signal Company. Porcelain is used everywhere as an insulator, except in the case of the coils and a block carrying the coil terminals.

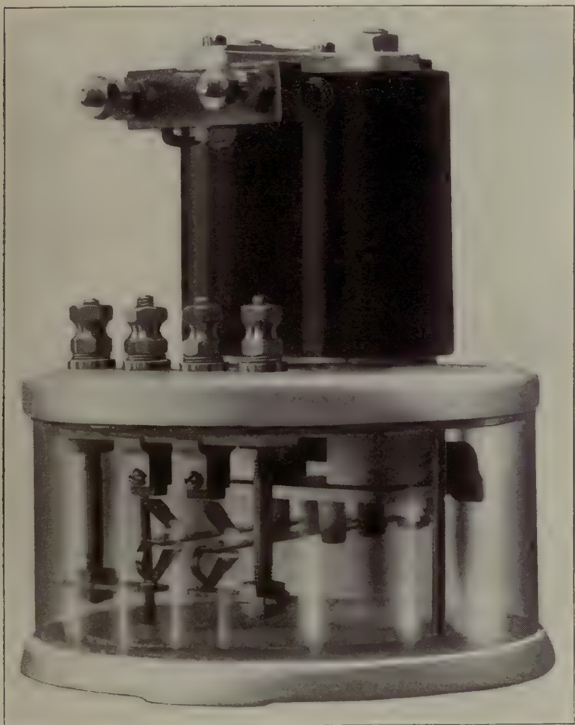


Fig. 3044. Model 9C Relay. 2 Front and 2 Back Points.

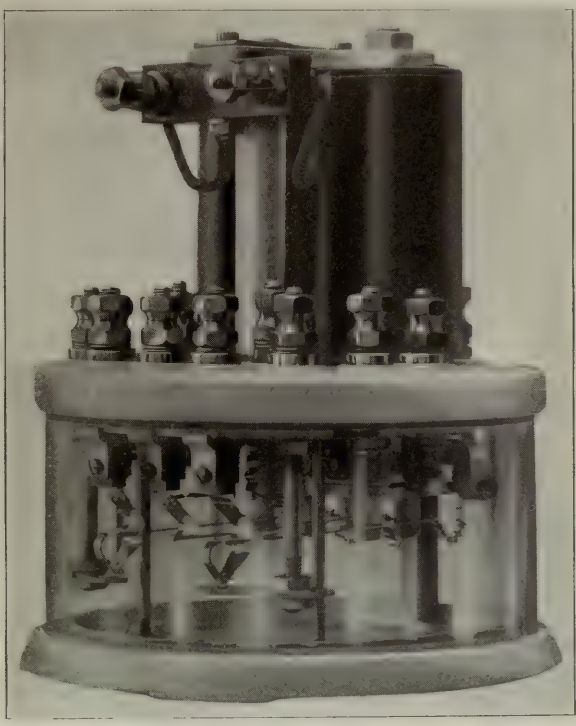


Fig. 3045. Model 9C Relay. 3 Front and 2 Back Points. The Union Switch & Signal Company.

The coils are wound on hard rubber spools, easily removable from the cores without disturbing the adjustment of the points. There are no concealed insulating bushings. The relays pass a ground test of 5,000 volts before leaving the shops.

HALL NEUTRAL RELAY.

Fig. 3047 shows the style "H" neutral relay made by the Hall Signal Co. It is glass-enclosed with metal base and "bakelite" top. The top or magnet support, being made of "bakelite,"

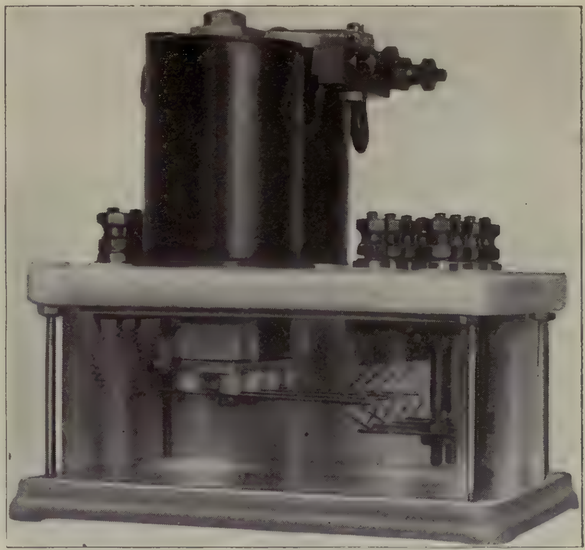


Fig. 3046. Union Model 9C Neutral Relay.

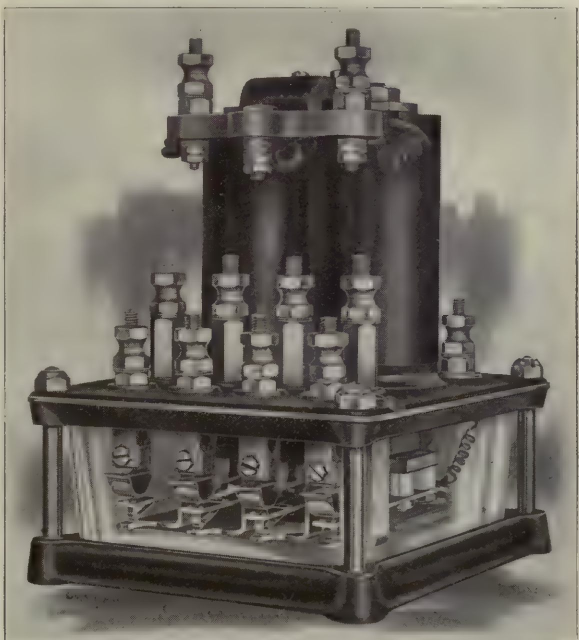


Fig. 3047. Style "H" Shelf Type Neutral Relay. Front View. Hall Signal Company.

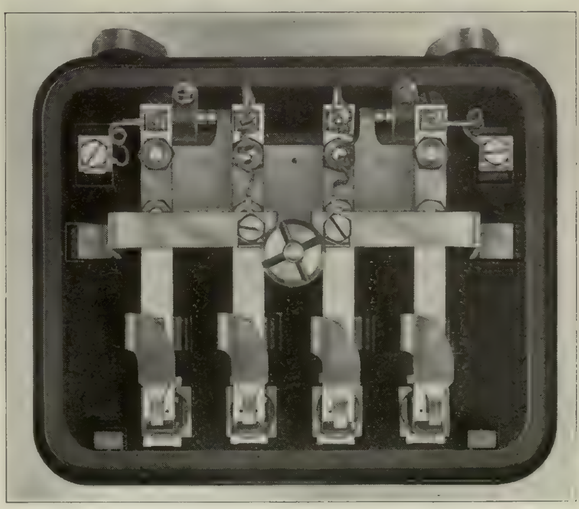


Fig. 3048. Bottom View, Style "H" Relay. Hall Signal Company.

dispenses with the use of insulating bushings or washers at binding posts. By a simple device, consisting of a square washer and snap ring, the binding posts carrying the front graphite contacts are locked in position and cannot be turned without first removing the glass case.

The most important feature of the style "H" relay lies in the use of a flexible silver gauze for the lower portion of the front contacts. This construction provides a contact of uniformly low resistance.

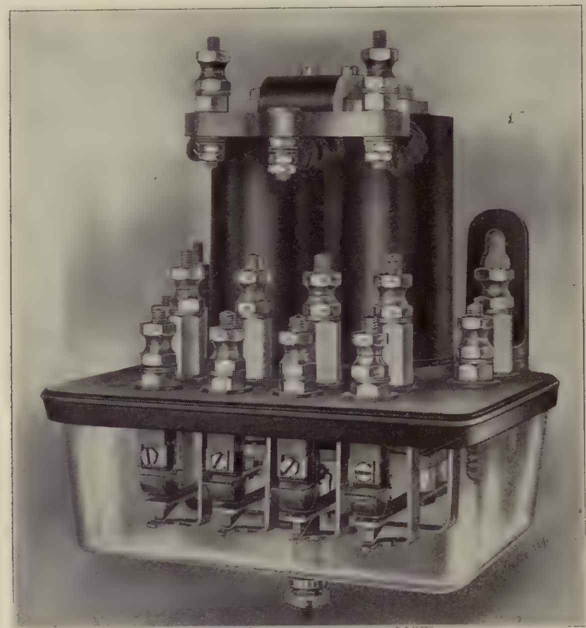


Fig. 3049. Style "H" Wall Type Relay with Gauze Contacts. Hall Signal Company.

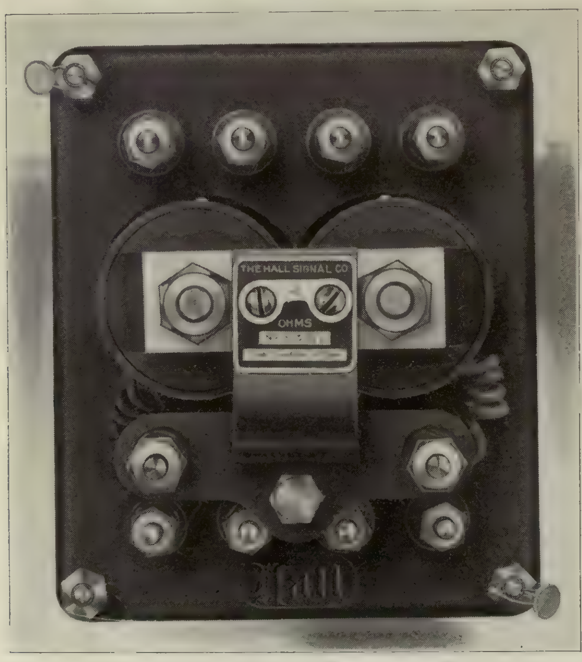


Fig. 3050. Style "H" Shelf Type Relay. Top View. Hall Signal Company.

The large area of the silver gauze in contact with the carbon affords great carrying capacity, and experience has shown that with this arrangement it is impossible for a fused contact to maintain a closed circuit.

This relay is built in both the wall and shelf type and in varying sizes up to eight front and eight back contacts.

RELAY WITH "EVERETT" MERCURY CONTACTS.

Fig. 3051 shows a relay made by The Hall Signal Co. having "Everett" mercury contacts. These contacts are used for breaking a front contact on a relay when the front contact is held closed without current by the tipping or improper position of the instrument.

There have been many instances recorded where a relay, especially of the shelf type, has been placed at such an angle as to maintain a circuit through the front contacts with the magnets de-energized.

This condition has also been produced by the relay post being bent or thrown out of position by a storm or otherwise. With the "Everett" contact no such dangerous condition can exist.

The mercury cup is attached to the rear binding posts of the relay, and is connected in series with the contacts. When, through carelessness or other cause, the relay is placed at an angle sufficient to close the front contacts, the mercury moves by gravity to the side of the cup and out of range of the platinum wire connectors, thus opening the circuit and preventing a false clear signal.

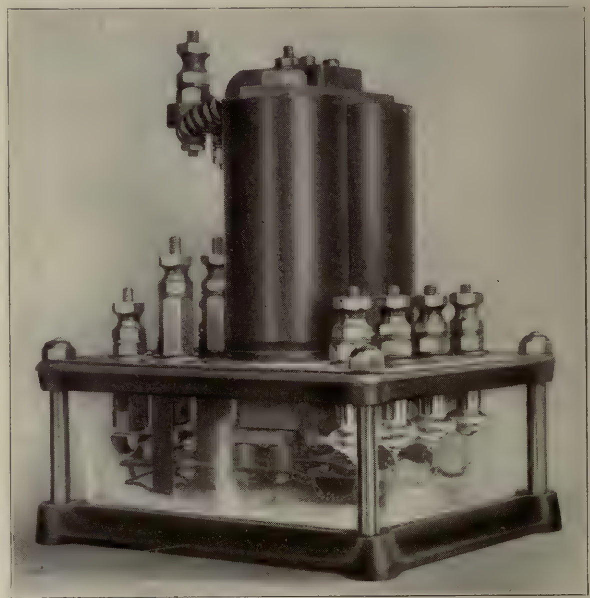


Fig. 3051. Relay with "Everett" Mercury Contacts. Hall Signal Company.

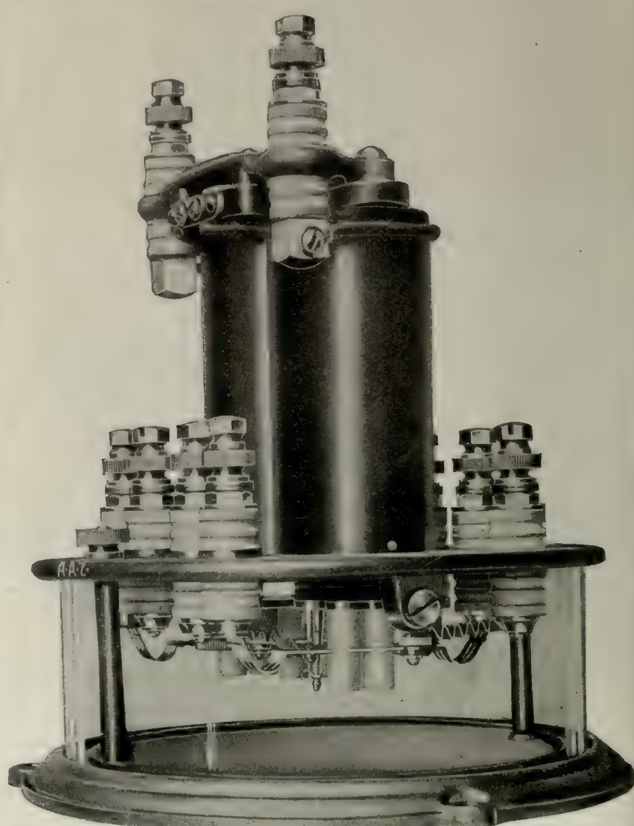


Fig. 3052. Type "B" Circular Track Relay, Four Front and Four Back Contacts. United Electric Apparatus Company.

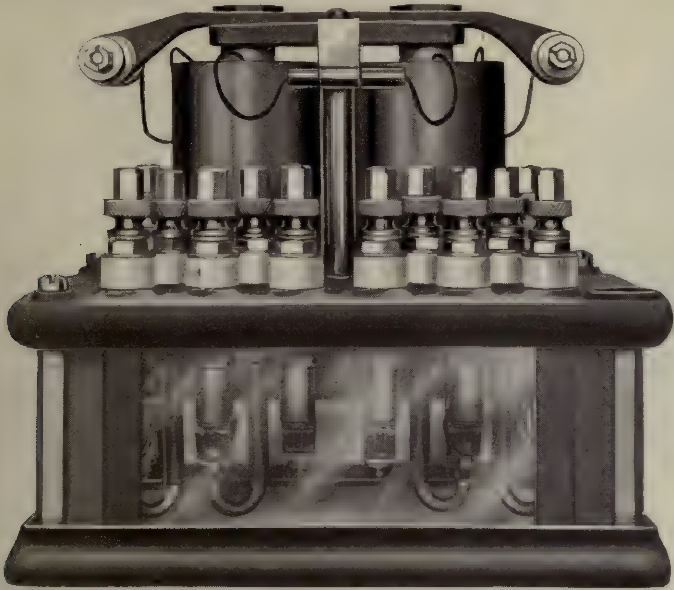
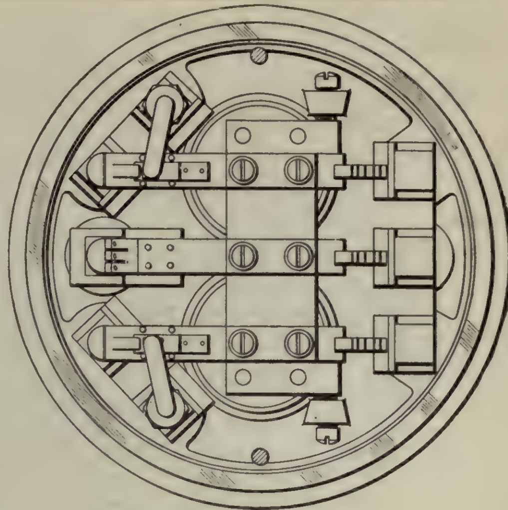
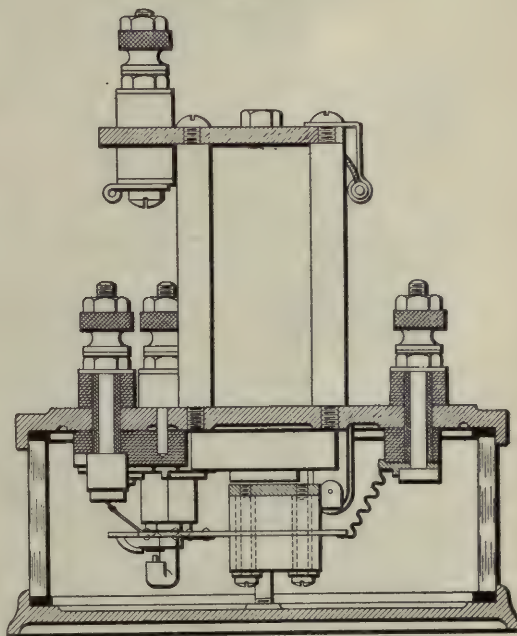


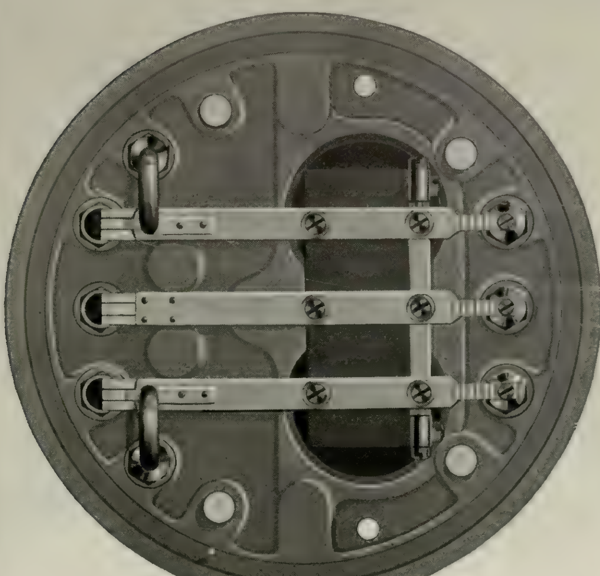
Fig. 3053. Union Model 9 Neutral Relay.

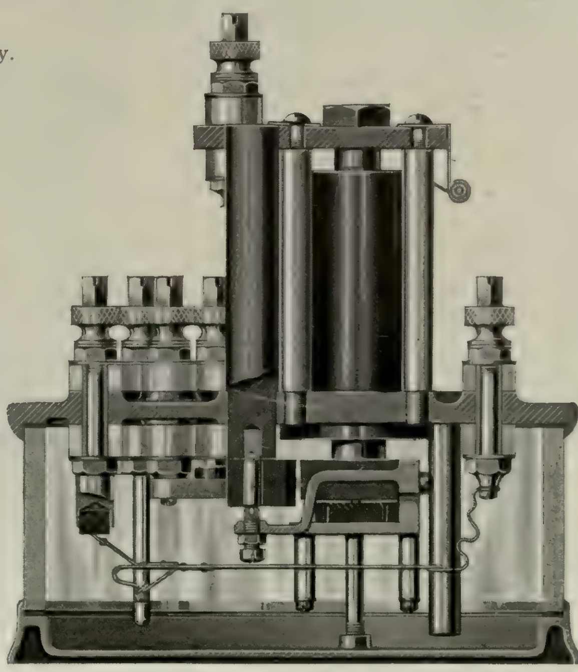




Figs. 3055-3056. Union Model 1C Relay.

Fig. 3054. Union Model 9 Neutral Relay.





Figs. 3057-3058. Model 2 Relay, Neutral Type; Inverted View, and Section. The Union Switch & Signal Company.

Fig. 3059. Plan of Union Model 1, Neutral Type Relay.

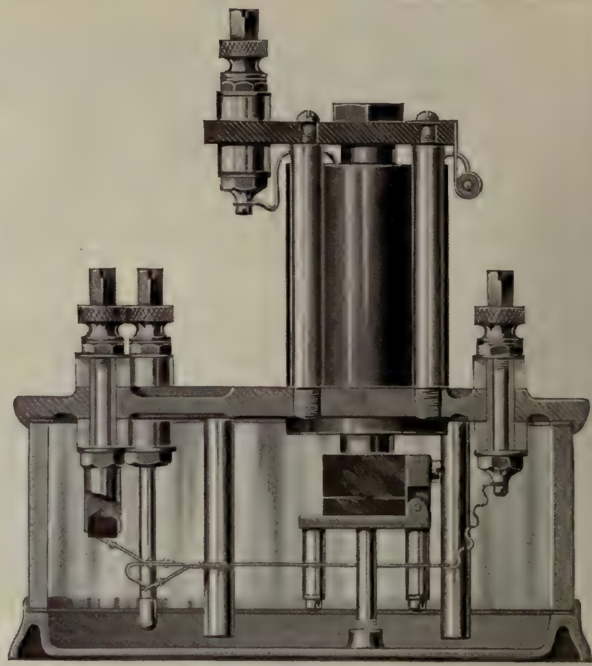


Fig. 3060. Sectional View of Union Model 1, Neutral Type Relay.

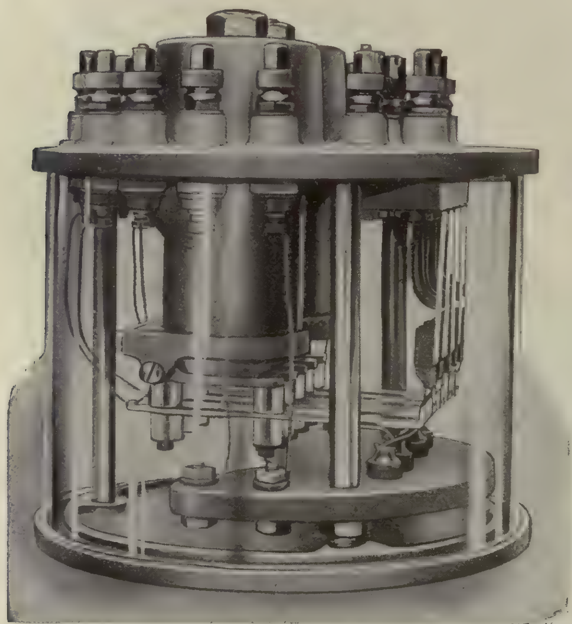


Fig. 3061. Neutral Enclosed Relay. American Railway Signal Company.

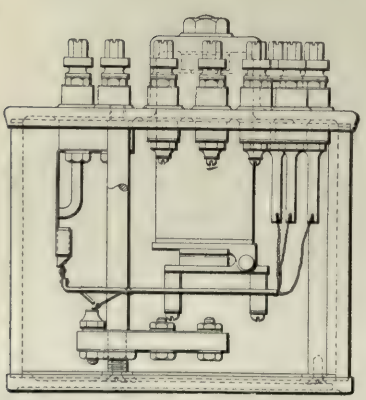


Fig. 3062. Neutral Enclosed Relay. American Railway Signal Company.

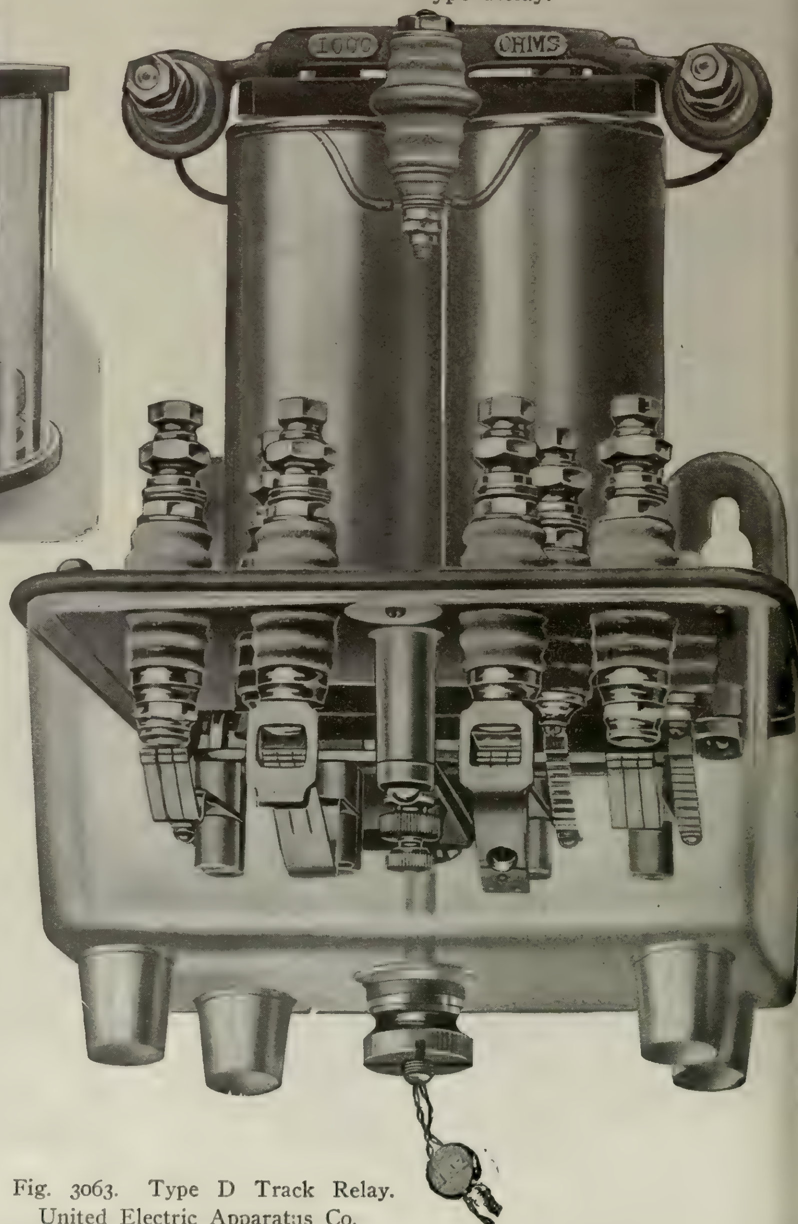


Fig. 3063. Type D Track Relay. United Electric Apparatus Co.

G. R. S. UNIVERSAL DIRECT CURRENT RELAYS.

In the G. R. S. Co.'s Model 9 relays and indicators, essentially the same parts are used, the magnet cores, yoke, armatures, insulations, binding posts, contacts, etc., being standard for all the devices of this line. Figs. 3065 and 3066 show views of the four and six point Model 9 Form A relays. The Model 9 Form A is also made in the wall type relay, as shown by Fig. 3068.

The Model 9 Form B is provided with "non-freezing" contacts, as a protection against lightning or other heavy currents. This feature consists of two semi-interlocked platinum contacts so arranged in series that should the working contact be frozen the secondary contact will be opened and locked open.

The Model 9 Form C relay, illustrated by Fig. 3069, is constructed so that the front contacts may be removed for the purpose of cleaning them without disturbing any of the other parts.

In the Model 9 polarized relay the neutral and polar magnetic circuits are entirely independent, the one not having any influence on the other.

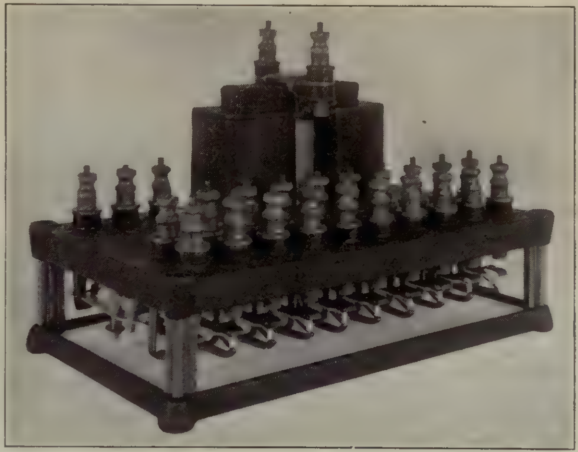


Fig. 3067. Model 19 A. C. Relay, 10-Way. General Railway Signal Company.

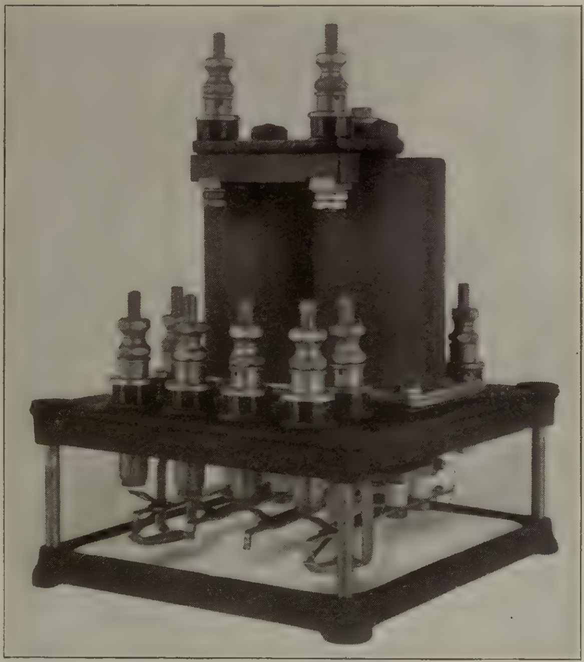


Fig. 3065. Universal D. C. Relay, Model 9, Form A, Four-Way.

Fig. 3068. Universal D. C. Relay, Model 9, Wall Type, 4-Way. General Railway Signal Company.

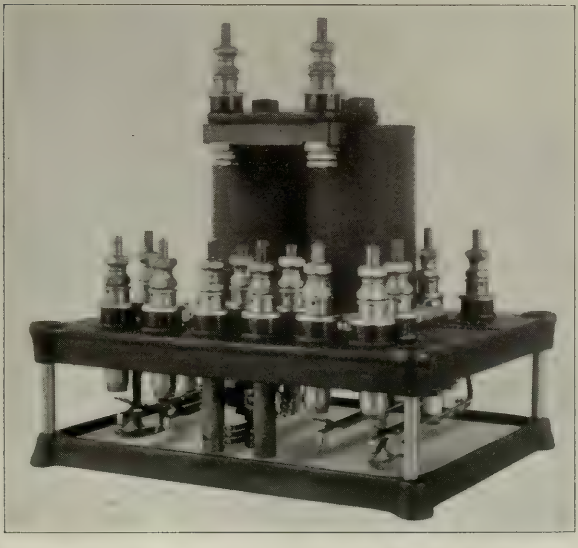


Fig. 3066. Universal D. C. Relay, Model 9, Form A, Six-Way. General Railway Signal Company.

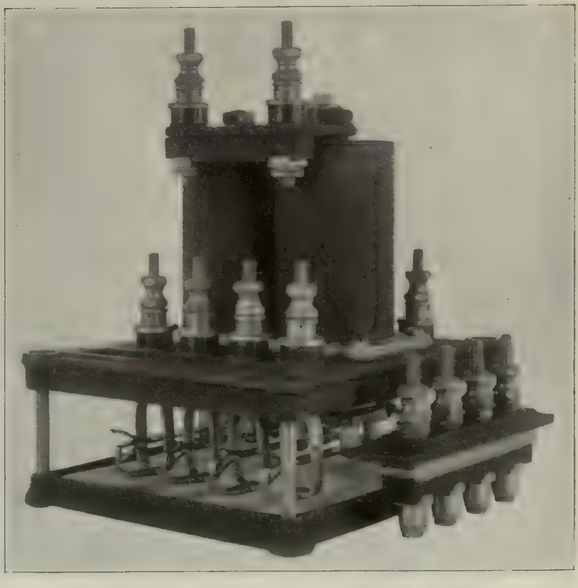


Fig. 3069. Universal D. C. Relay, Model 9, Form C. (Removable Contacts.) 4-Way. General Railway Signal Company.

Figs. 3065-3069. Relays. General Railway Signal Company.

Fig. 3070. Type "E" Enclosed Line Relay. United Electric Apparatus Company.

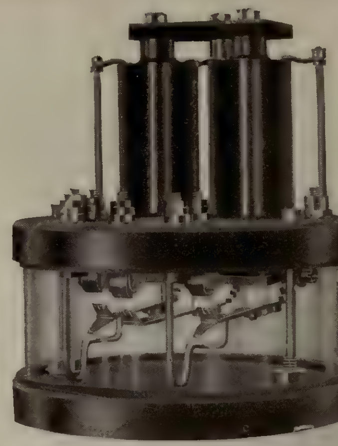


Fig. 3072. Enclosed Neutral Relay. Railroad Supply Company.

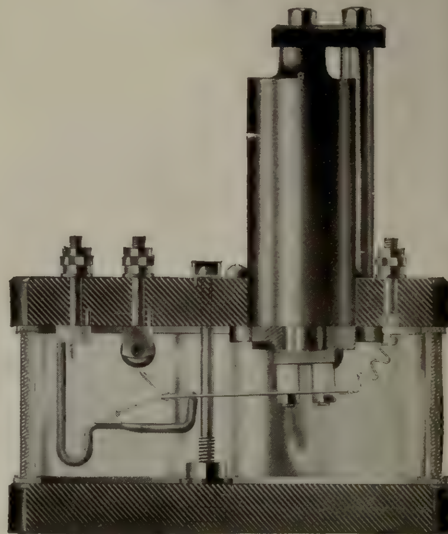


Fig. 3073. Sectional View of Relay Shown in Fig. 3072.

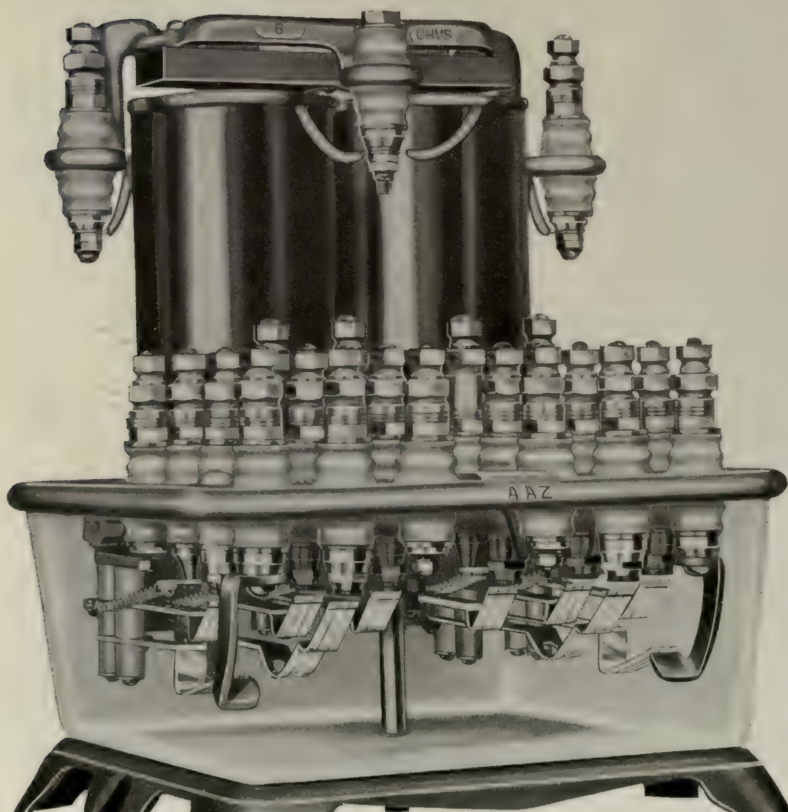


Fig. 3071. Type "H" Enclosed Relay. United Electric Apparatus Company.

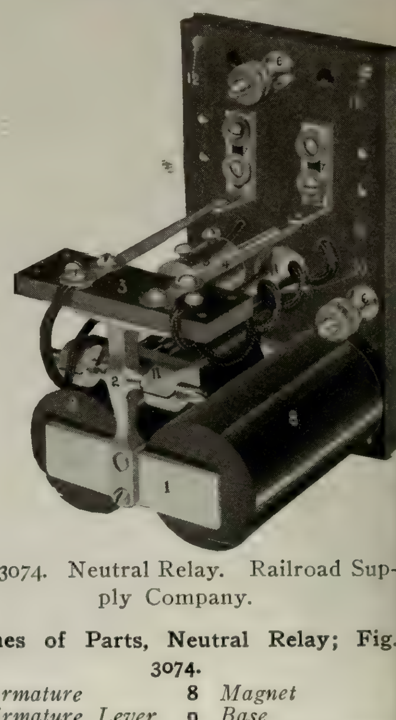


Fig. 3074. Neutral Relay. Railroad Supply Company.

Names of Parts, Neutral Relay; Fig. 3074.

1	*Armature*	8	*Magnet*
2	*Armature Lever*	9	*Base*
3	*Spring Support*	10	*Flexible Connection*
4	*Contact Spring*		
5	*Counterweight*	11	*Trunnion Support*
7	*Contact Block*		

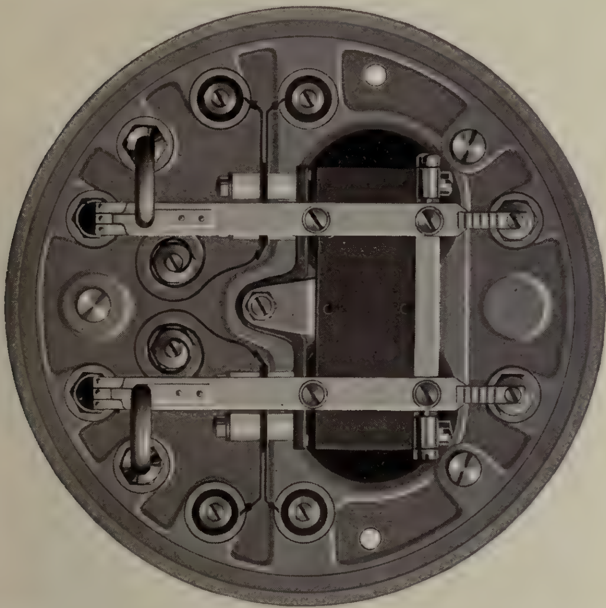


Fig. 3075. Inverted View, Showing Arrangement of Neutral Armature and Contacts, Model 1 Relay Polarized Type.

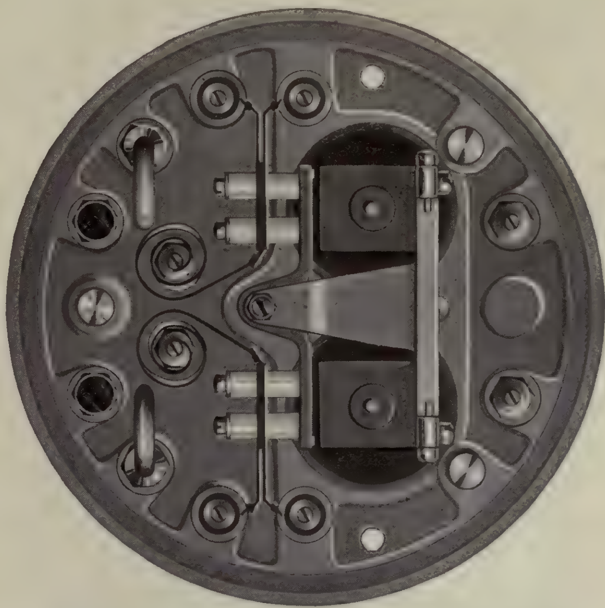


Fig. 3076. Inverted View Showing Arrangement of Polarized Armature and Polar Contacts. Model 1 Relay Polarized Type.

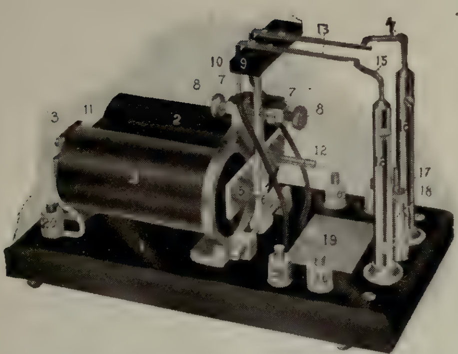


Fig. 3078. Neutral Relay. Railroad Supply Company.

The G. R. S. Model 9 polarized relay is of the same size and construction as the neutral relay except for the addition of a permanent magnet and polarized armature with the necessary contacts. The polarized armature, one end of which swings between the neutral pole pieces, is suspended below the permanent magnet. The principles involved in its operation are the same as in the case of the Union Universal relay, Figs. 3075-3077.

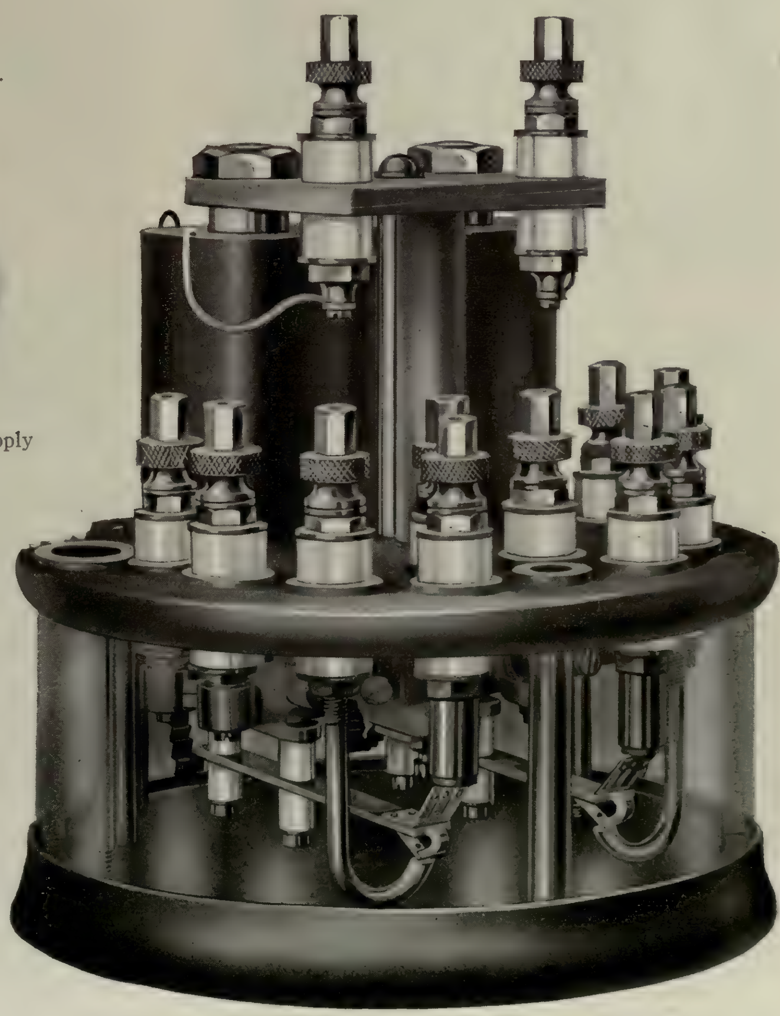


Fig. 3077. Model 1 Relay. Polarized Type. The Union Switch & Signal Company.

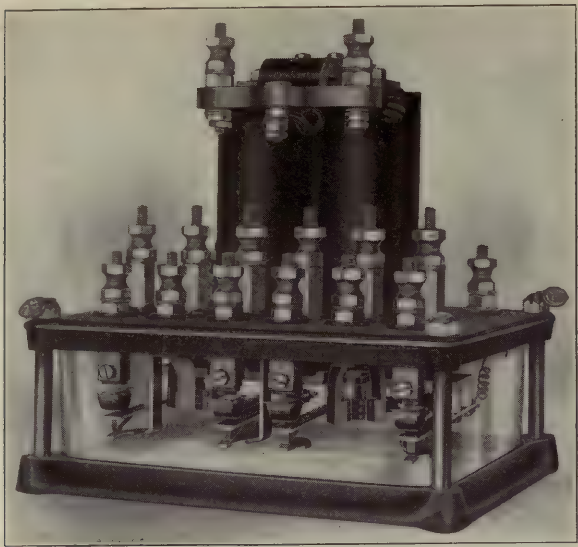


Fig. 3079. Neutral Polar Relay, Front View. Hall Signal Company.

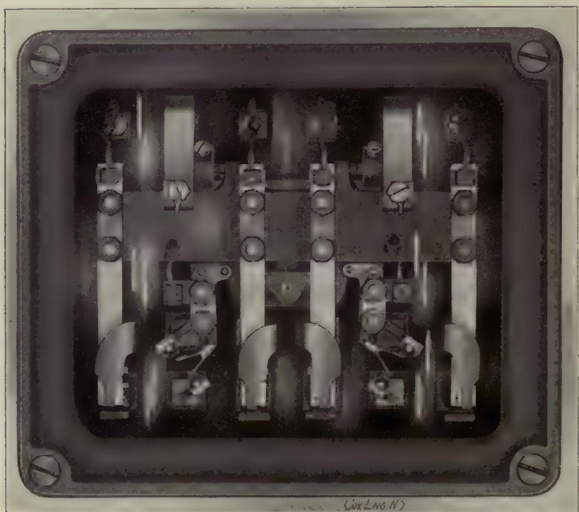


Fig. 3080. Neutral Polar Relay, Bottom View.

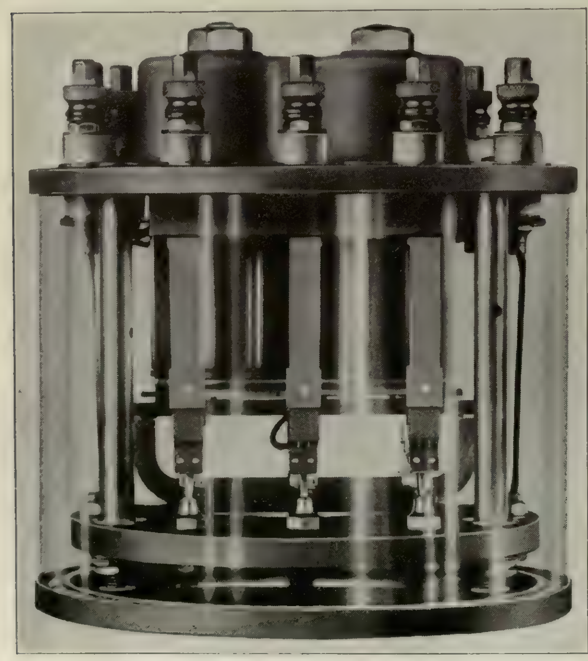


Fig. 3081. Three-Point Quick Release Relay, Front View. American Railway Signal Company.

HALL POLARIZED RELAY.

The neutral polar relay of the Hall Signal Co., shown in Fig. 3079, is of the glass-enclosed type, and consists of a neutral and a polarized armature, with magnets and binding posts mounted on a bakelite top.

The polarized armature is a permanent magnet, horizontally pivoted at center and provided at each end with either one or two silver or platinum contacts as desired.

The neutral armature carries from one to four contact fingers, with silver gauze front contacts, and either silver or platinum back contacts.

Base, glass case and top are held together by four corner screws, two of which, located diagonally opposite, are provided with means for attaching the Hall metal seal.

The relay top is made of bakelite.

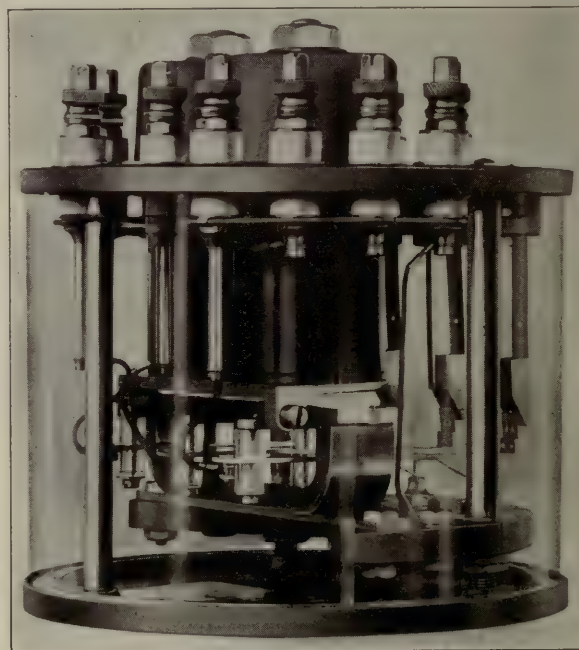


Fig. 3082. Rear View of Three-Point Quick Release Relay. American Railway Signal Company.

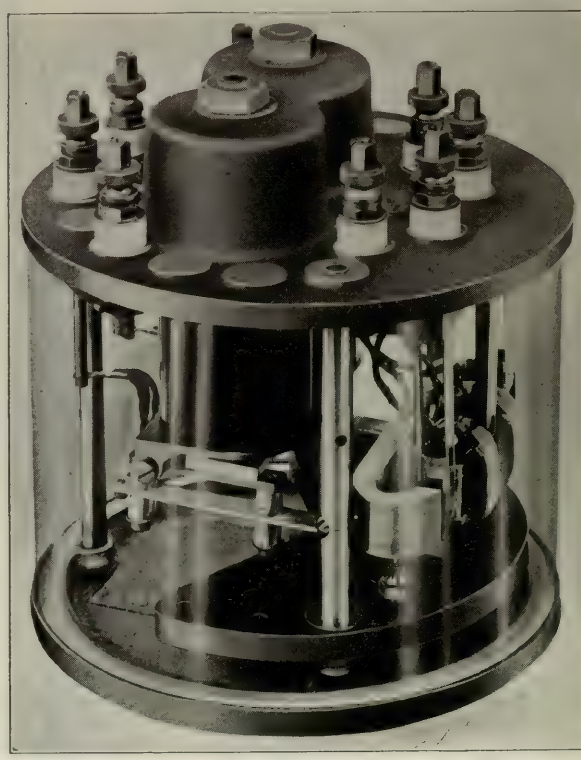


Fig. 3083. Two-Point Heavy Current Relay with Blow-out Magnets. American Railway Signal Company.

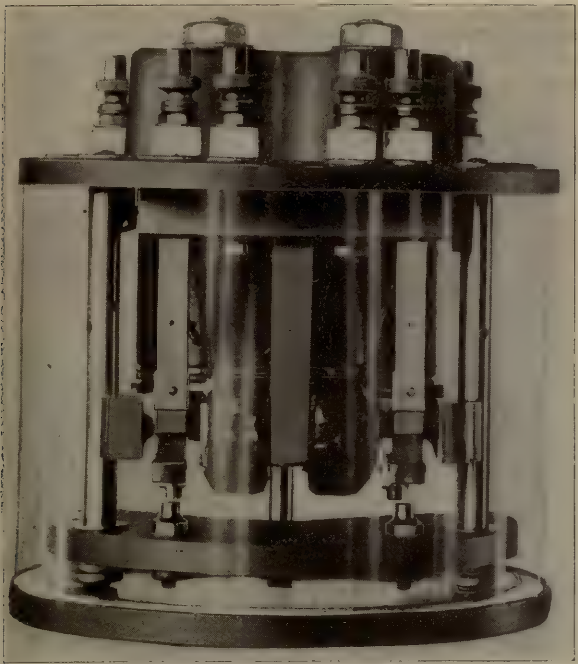


Fig. 3084. Two-Point Heavy Current Relay with Blow-out Magnets. American Railway Signal Company.

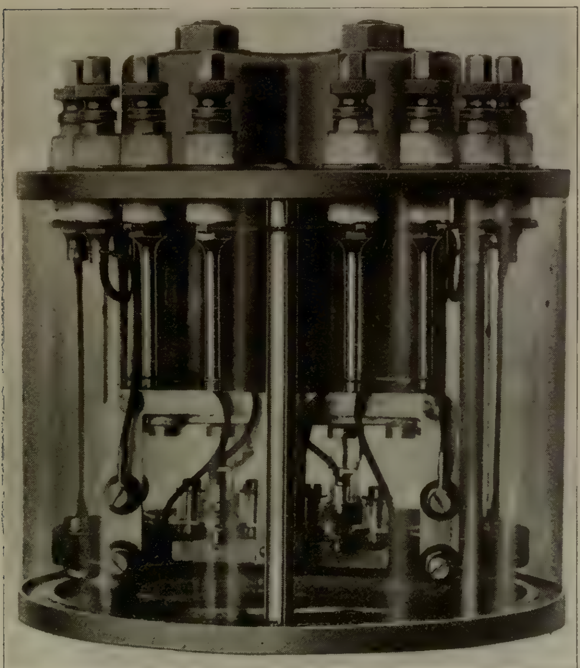


Fig. 3085. Polarized Relay. Back View. American Railway Signal Company.

UNION GALVANOMETER TYPE A. C. TRACK RELAY.

Fig. 3087 shows a two-element relay, designed originally for use on electric roads. When used on steam roads, the mechanical construction is the same, the winding only being changed.

The two large coils are the field winding and are connected to a local source of alternating current. The moving coil is the armature winding and is connected to the track. The shaft carrying the moving coil is connected by cranks and a link to a second shaft, which carries the contact springs.

To operate the relay it is necessary to have current flowing to both windings, and these currents must be in a certain direction relative to each other. In case direct current flows through the armature, it cannot operate the relay, since the fields are energized with alternating current.

The relay contains no iron in its magnetic circuit and therefore it cannot be held closed by direct current flowing through the armature after the alternating current has been shunted off. If the polarity of adjacent track circuits is reversed, current coming from the adjacent track circuit in case the insulated joints are broken down, will tend to open the relay contacts. The clearances in the relays are large.

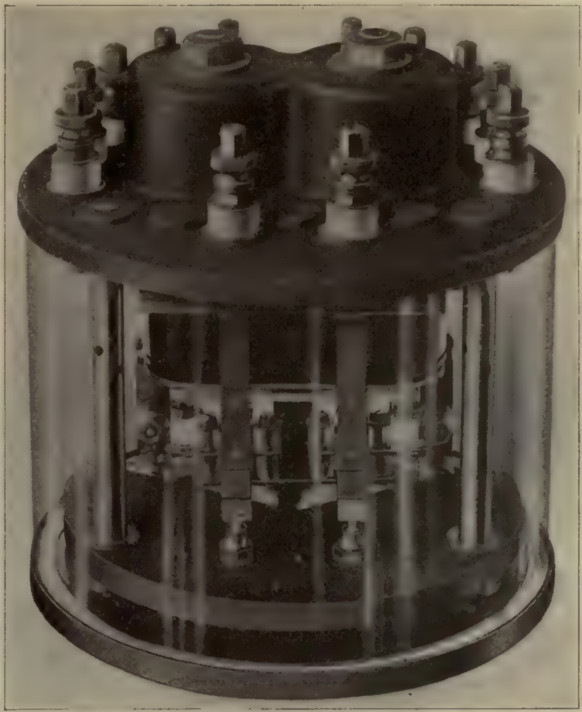


Fig. 3086. Front View of Polarized Relay. Two Neutral Front and Back Contacts, Two Polarized Front and Back Contacts. American Railway Signal Company.

UNION RADIAL CONTACT RELAYS.

The advantages of the radial contact system are accessibility of binding posts and the opportunity which the arrangement of the contact system permits for inspection of, and easy access to the operating mechanism. The second characteristic is especially desirable when the operating mechanism involves small clearances between stationary and moving parts, such as are necessary for high economy of power consumption in the induction motor type of relay.

Fig. 3087. Galvanometer Type A. C. Relay. Union Switch & Signal Company.

The divisions of the case and the porcelain contact carrier are assembled with dust-proof gaskets, but can be readily taken apart, this making it easy to make the changes in points necessary to get any desired combination of front and back contacts, or to make renewals of wearing parts.

By employing porcelain for the mounting of the contact posts and for the driving piece which imparts motion to the movable parts of the contacts, the radial system avoids the use of concealed bushings. The binding posts are non-turning and com-

ply with Railway Signal Association requirements. The radial contact relay can be used as either a track or line relay.

The holding clear device is placed in a perfectly accessible position, with its movable members housed within a sealed compartment, secured to the frame. In other words, the magnet

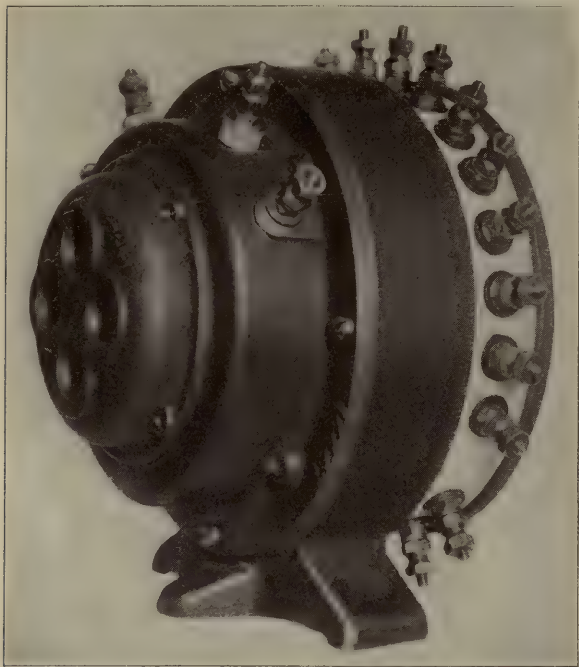


Fig. 3088. Induction Motor Type Radial Contact Relay. The Union Switch & Signal Company.

and controlling elements of the clutch, or slot, are stationary, easily detached, accessible, and are out of reach of the weather during inspection or other attention to the mechanism in inclement weather.

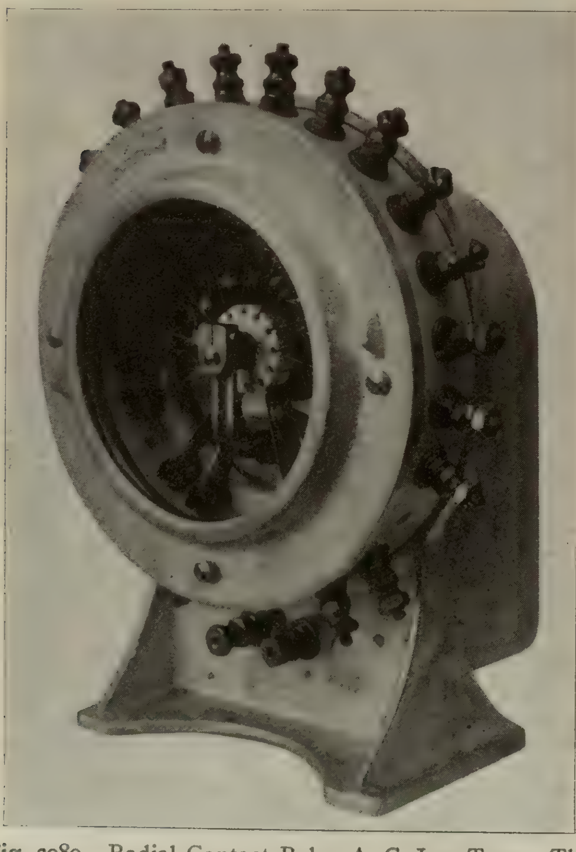


Fig. 3089. Radial Contact Relay A. C. Jaw Type. The Union Switch & Signal Company.

In the two-position forms of this signal a simple a. c. or d. c. motor is used with a mechanically actuated brake, which, as the signal is moved to the clear position, is suddenly applied to arrest the momentum of the motor; the application being also accompanied by a quick interruption of the motor circuit. This arrangement insures the interruption of the motor current before the brakes become effective.

When the signal returns to stop, the brake is positively released and the break in the motor circuit is again established. In the three-position type of mechanism a magnetic clutch is employed instead of a mechanical brake. This clutch is ener-

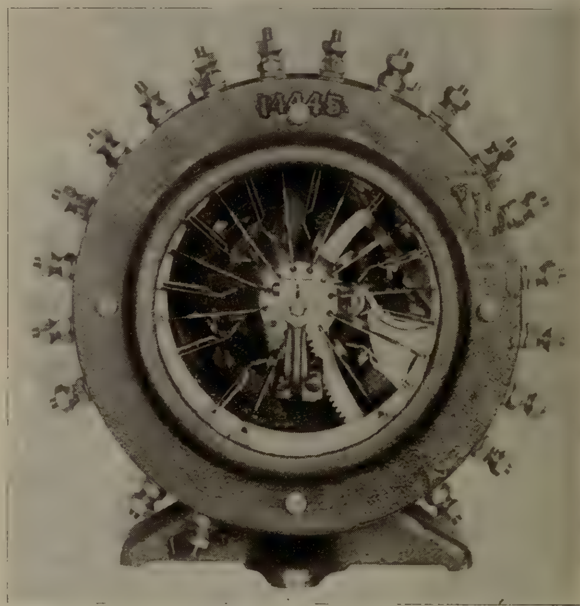


Fig. 3090. Radial Relay Induction Motor Type. The Union Switch & Signal Company.

gized with the motor and causes the motor pinion to revolve with the armature positively at such times. When current to them is interrupted, the armature is disengaged from the pinion and the armature is thus permitted to come to rest at will,

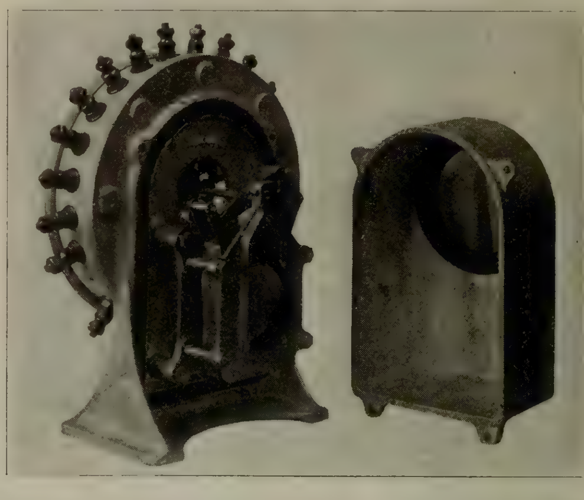


Fig. 3091. Radial Type Relay A. C. Jaw Type. Union Switch & Signal Company.

while the pinion and the other gearing of the signal come to rest practically instantaneously. This latter effect is assured and the backward movement of the gearing by the signal is prevented by the release of the motor clutch acting as a brake upon the pinion shaft.

UNION ELECTRO-PNEUMATIC RELAY.

The electro-pneumatic relays illustrated are of the types installed on the Pennsylvania Tunnel & Terminal Railroad. The energizing of magnet F forces the valve stem of valve G up and permits air to pass through piping 27 to bottom of cylinder C, driving piston 3 up and in turn raises contact block E, and by so doing makes contact with springs on contact spring board D. The de-energizing of magnet F permits the air to escape through valve G, and by means of the coil springs 12 the contacts are forced open. With this relay the number of contacts and combinations are practically unlimited.

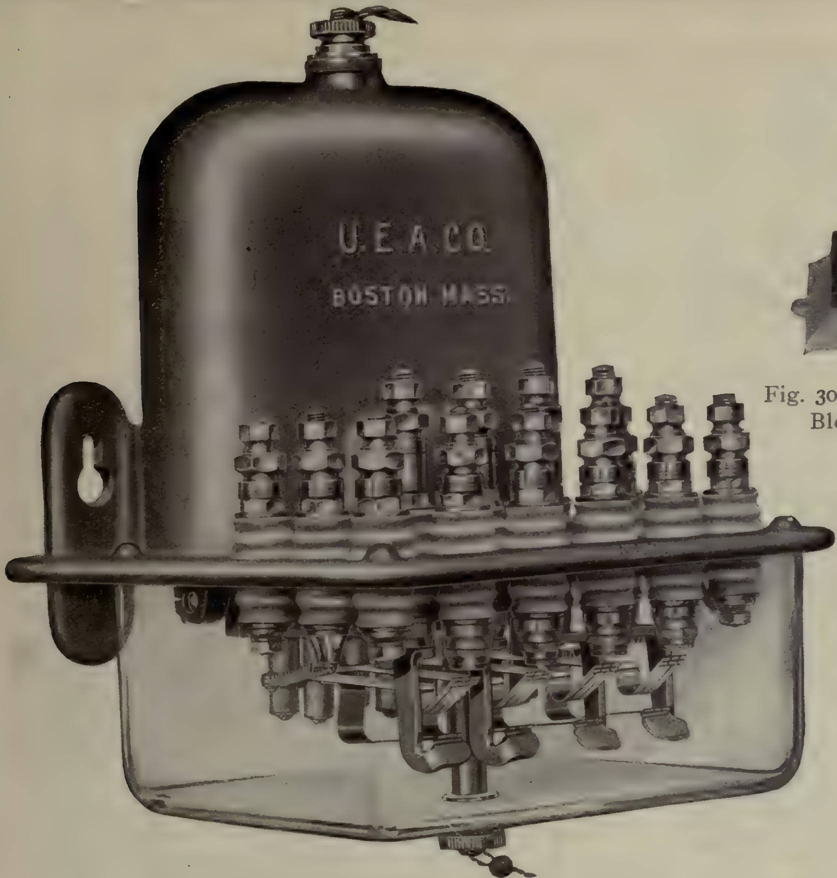


Fig. 3092. Type "E" Relay A. C. or D. C. United Electric Apparatus Company.

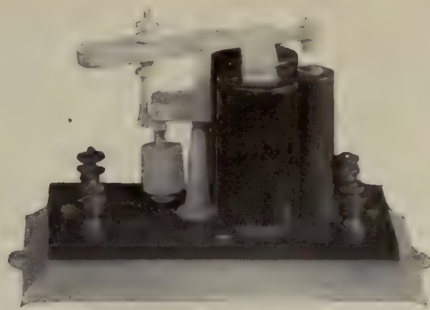


Fig. 3093. Heavy Current Relay (Magnetic Blow-Out). General Railway Signal Company.

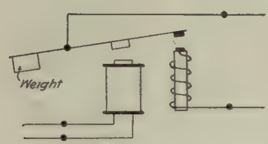


Fig. 3094. Circuit Diagram for Fig. 3097.

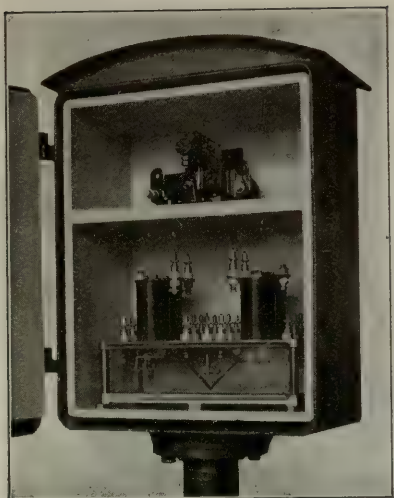
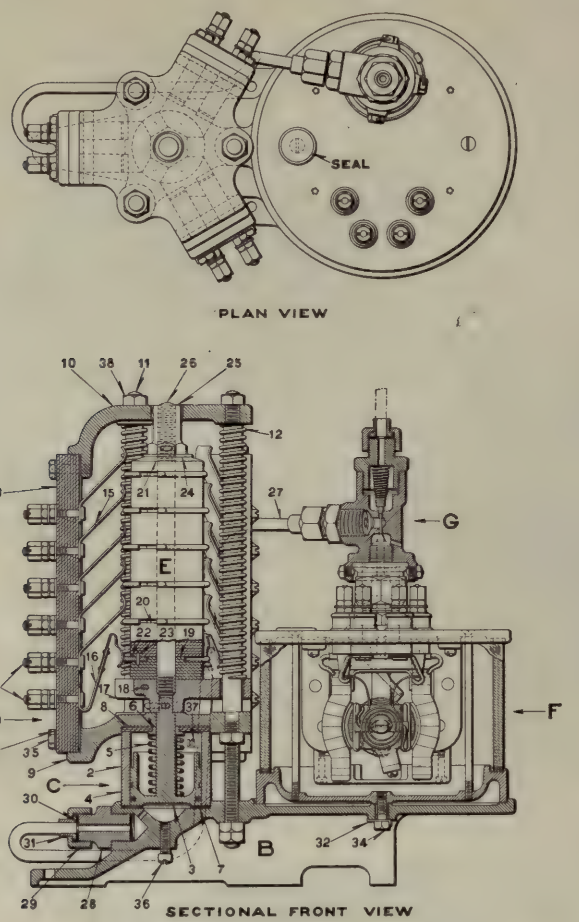
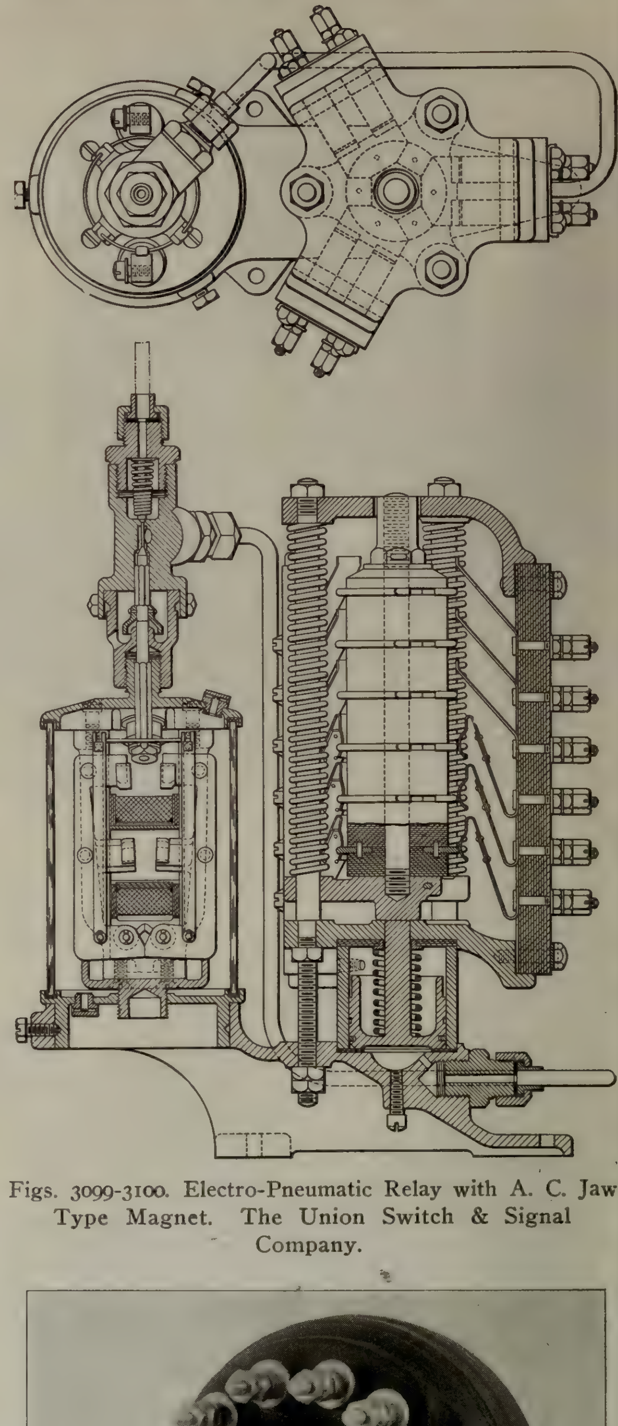


Fig. 3095. Relay in Iron Relay Box. Bryant Zinc Company.

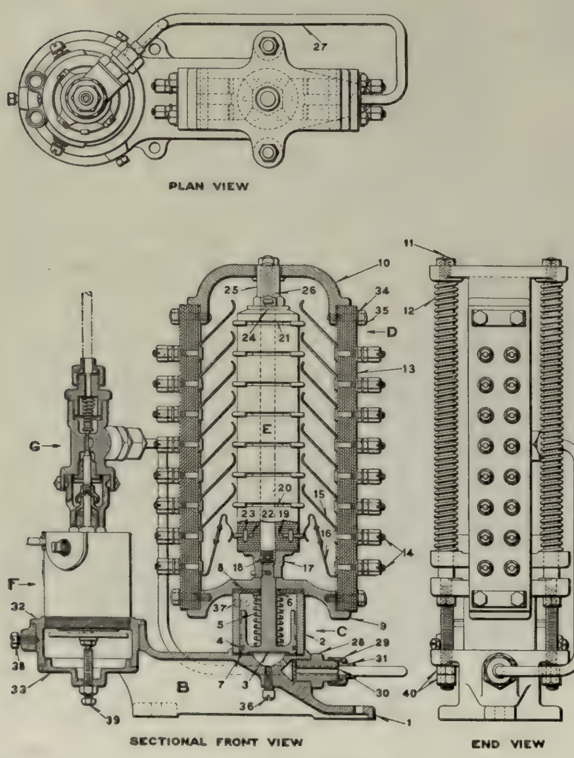
Fig. 3096. Type "E" Polarized Relay. United Electric Apparatus Company.



Figs. 3097-3098. Electro-Pneumatic Relay. The Union Switch & Signal Company.



Figs. 3099-3100. Electro-Pneumatic Relay with A. C. Jaw Type Magnet. The Union Switch & Signal Company.



Figs. 3101-3102. Electro-Pneumatic Relay with A. C. Jaw Type Magnet. The Union Switch & Signal Company.

Fig. 3103. Universal Polyphase Wall Type Relay, Model 2, Form B. General Railway Signal Company.

RELAY HOUSINGS, MOUNTINGS AND CABLE POSTS

Fig. 3104. Iron Relay Box Mounted on Iron Stub Post and Concrete Foundation. Bryant Zinc Company.

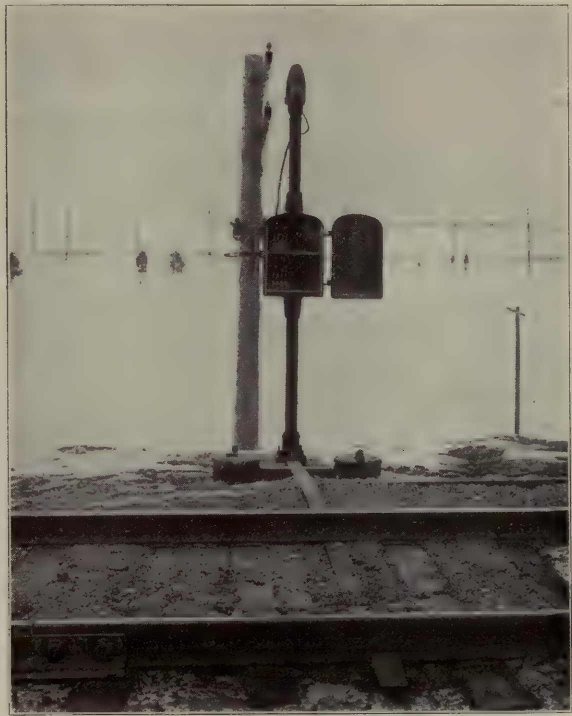


Fig. 3106. Relay Box and Cable Post. Northern Pacific. General Railway Signal Company.

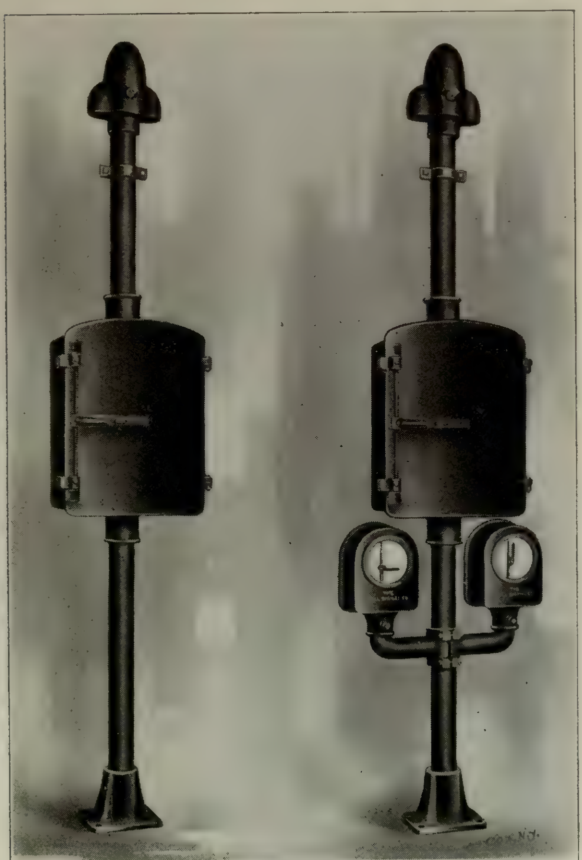


Fig. 3105. Cable and Relay Box Post; and Cable, Relay, and Indicator Post with Indicators. Hall Signal Company.

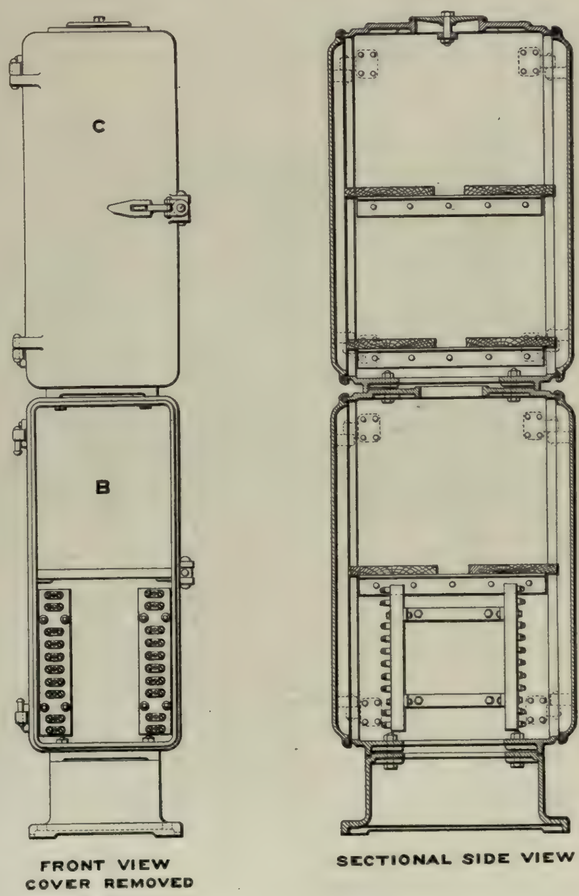
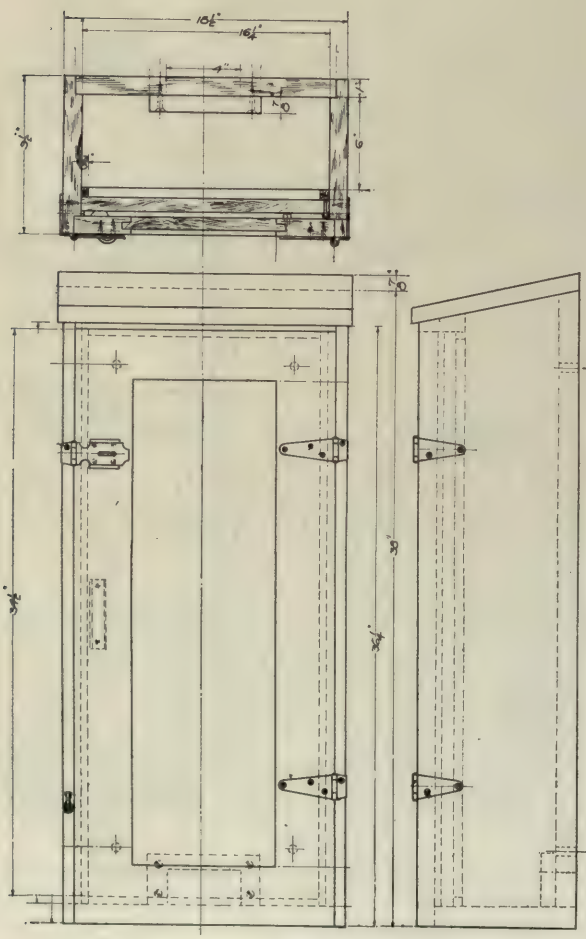


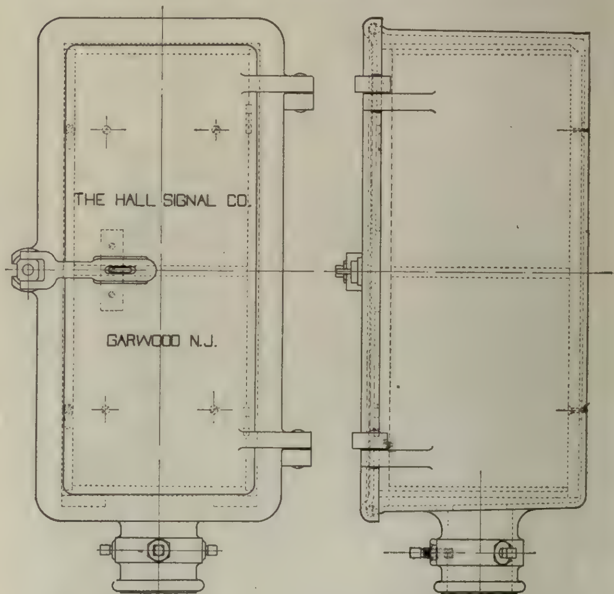
Fig. 3107. Vertical Relay and Terminal Case. The Union Switch & Signal Company.

Fig. 3108. Switch Indicator and Cable Post. Northern Pacific. General Railway Signal Company.

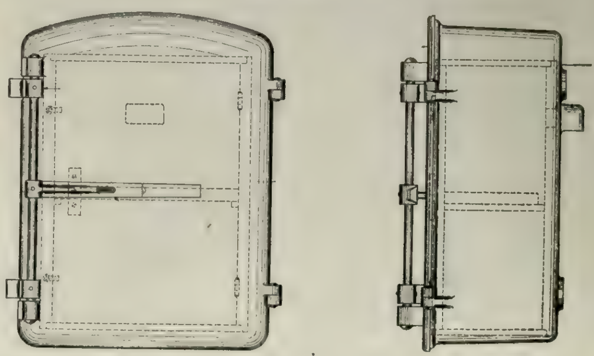
Fig. 3109. Relay Box, Indicator, and Cable Post. Northern Pacific. General Railway Signal Company.



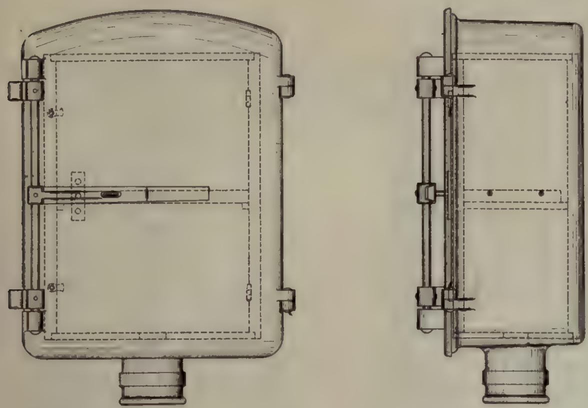
Figs. 3110-3112. Standard Relay Box for Four Relays. Hall Signal Company.



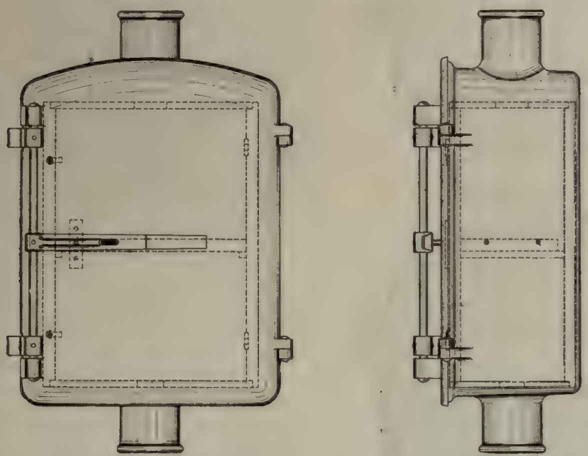
Figs. 3113-3114. Iron Relay Box. Hall Signal Company.



Figs. 3115-3116. Iron Relay Box Complete. Hall Signal Company.



Figs. 3117-3118. Iron Relay Box Complete for Three-Inch Pipe. Hall Signal Company.



Figs. 3119-3120. Iron Relay Box Complete for Three-Inch Pipe. Hall Signal Company.

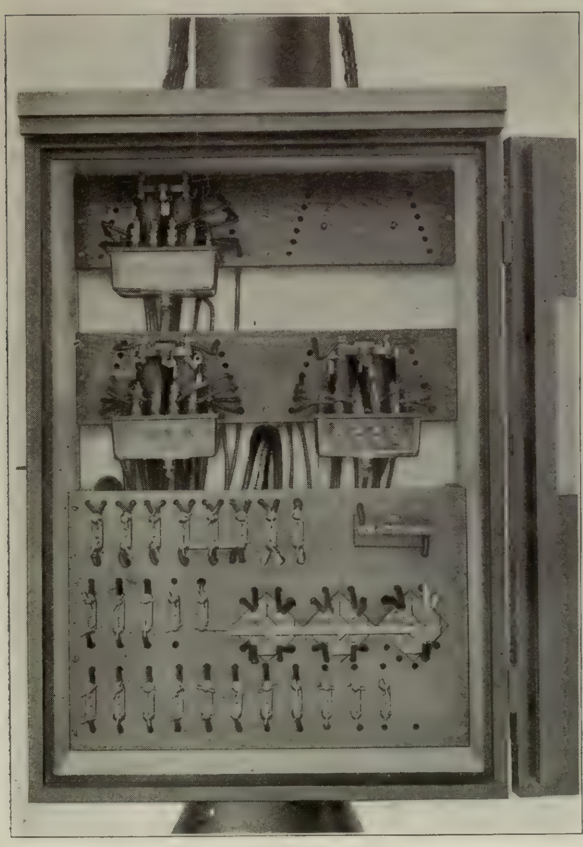
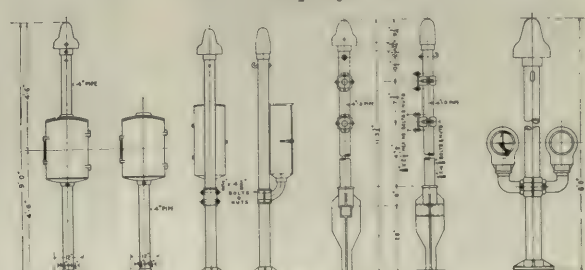


Fig. 3121. Relays and Relay Box. Hall Signal Company.

Fig. 3122. Grid Resistance and Polyphase Relays. New York Central. General Railway Signal Company.

Fig. 3123. Model 9 Relays and Relay Box on Signal Post. Northern Pacific. General Railway Signal Company.



Figs. 3124-3130. Cable Posts with Relay Boxes and Indicators.

Fig. 3131. Iron Relay Box with Universal Relays and Lightning Arresters in Place. The Union Switch & Signal Company.

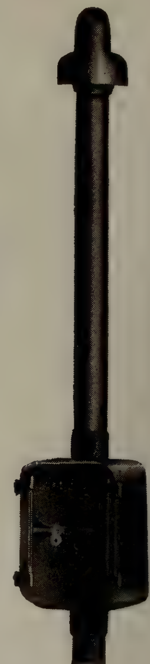


Fig. 3135. Relay Box and Cable Post. [When Mounted on Double Battery Chute, Same Attachments are used as in Fig. 3136 below.] Bryant Zinc Company.

Fig. 3133. Iron Relay Box for Crossing Bell Post. The Union Switch & Signal Company

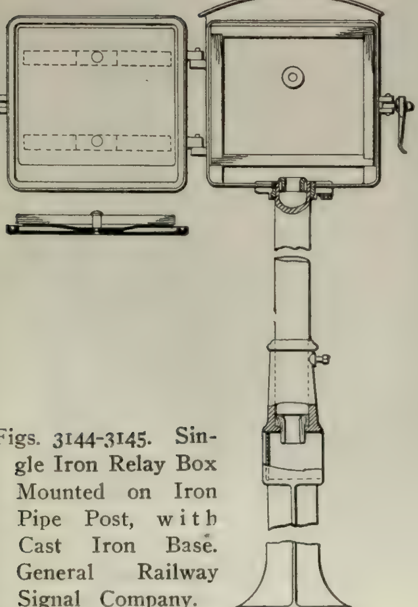
Fig. 3132. Relay Box and Battery Chute. Great Northern.

Fig. 3134. Wooden Relay Box with Frost Door. Railroad Supply Company.

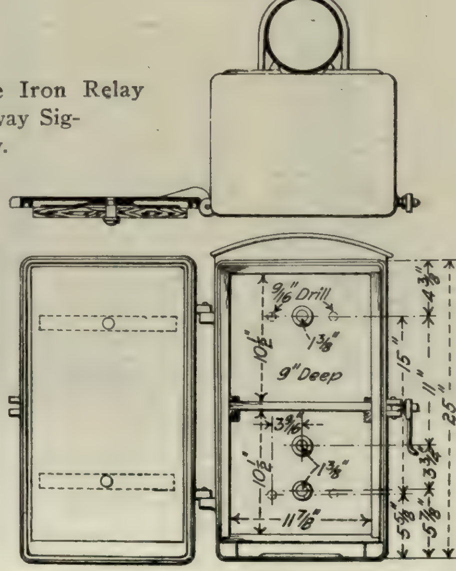
Fig. 3136. Relay Box Mounted on Double Battery Chute. Bryant Zinc Company.

Figs. 3137-3138.
Cast Iron Instrument Case.
The Union Switch &
Signal Company.

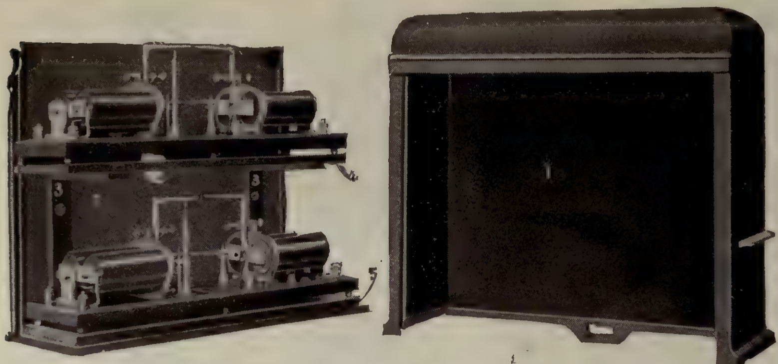
Figs. 3139-3143. Single Cast Iron Battery Chute with Cast Iron Post and Relay Box. Union Switch & Signal Company.



Figs. 3144-3145. Single Iron Relay Box Mounted on Iron Pipe Post, with Cast Iron Base. General Railway Signal Company.



Figs. 3146-3147. Double Iron Relay Box. General Railway Signal Company.



Figs. 3148-3149. Two Interlocking Relays in Case. Railroad Supply Company.

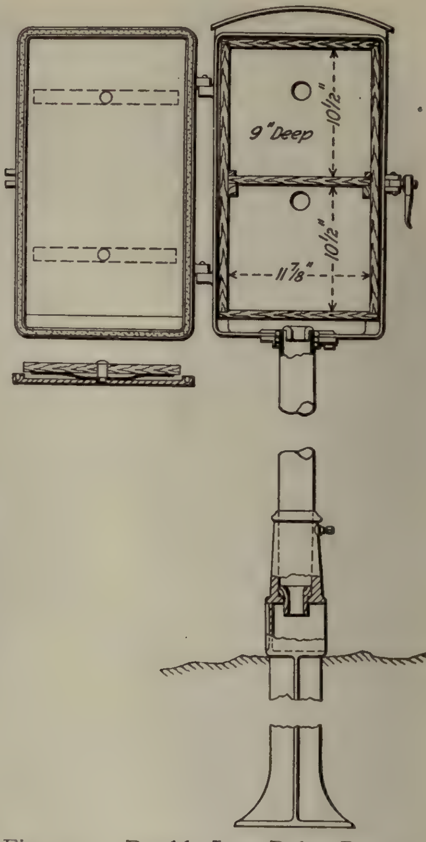


Fig. 3150. Relay Box. Railroad Supply Company.

Fig. 3151. Double Iron Relay Box on Iron Pipe Post. General Railway Signal Company.

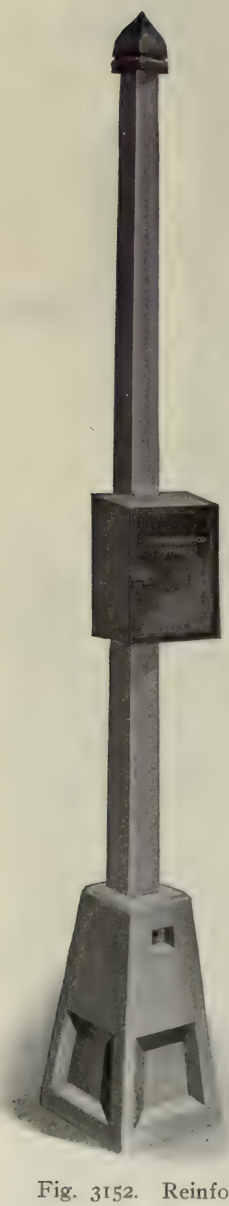


Fig. 3152. Reinforced Cement Relay Box Post and Foundation. C. F. Massey Company.

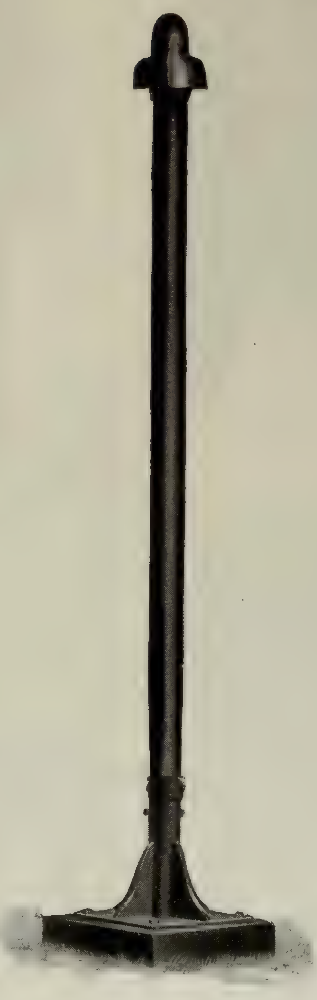


Fig. 3153. Cable Post Bryant Zinc Company.

Fig. 3154. Cable Post and Relay Box. Bryant Zinc Company.

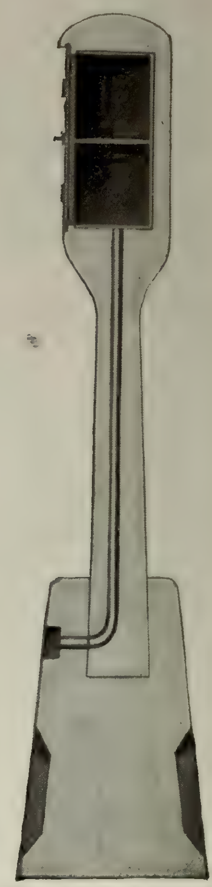
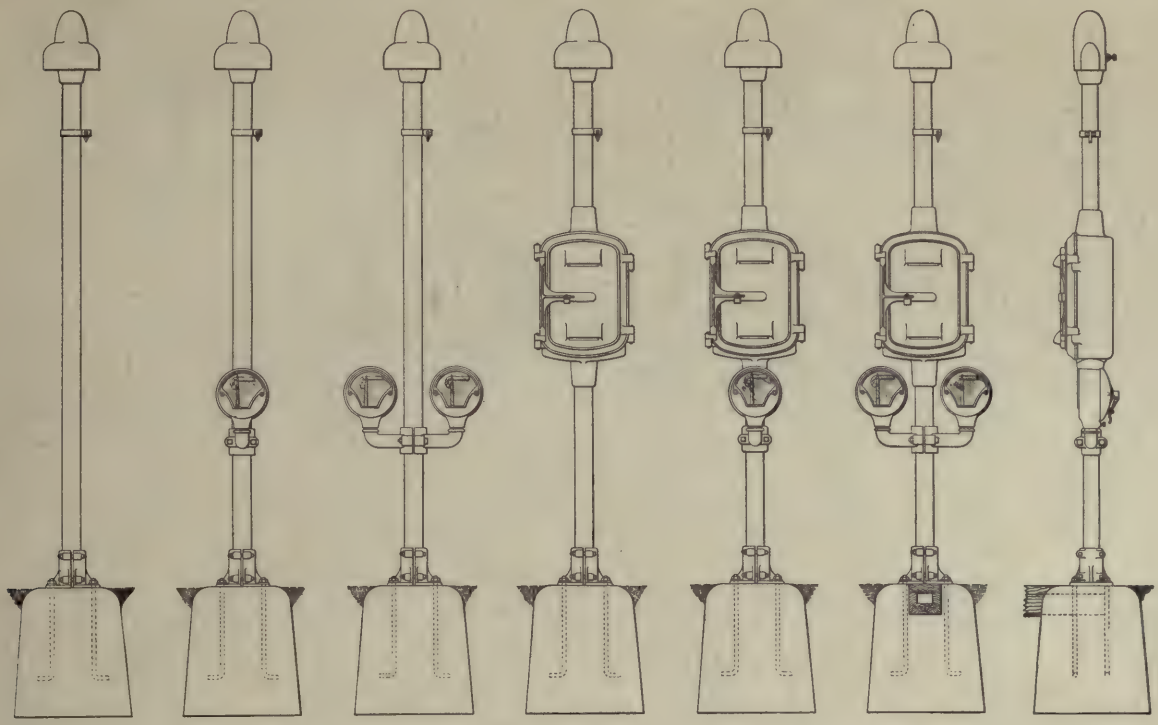
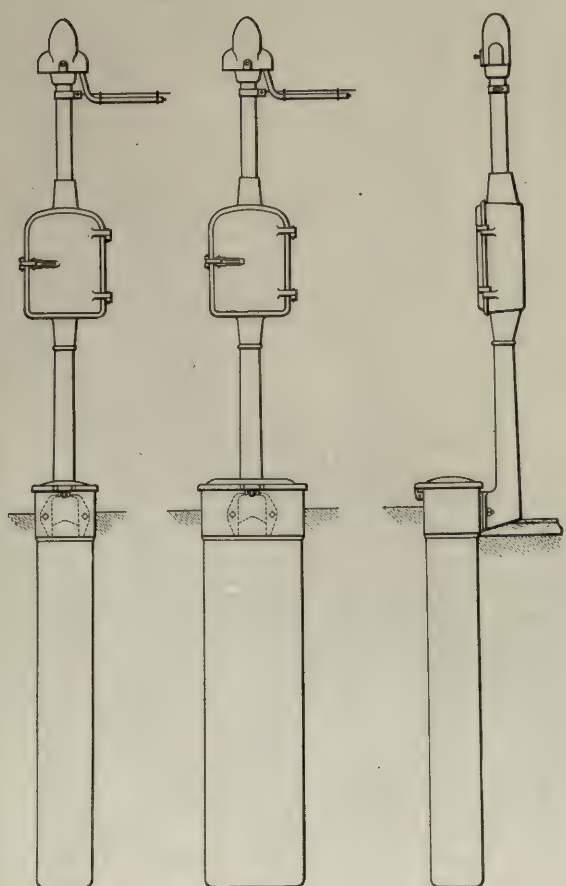


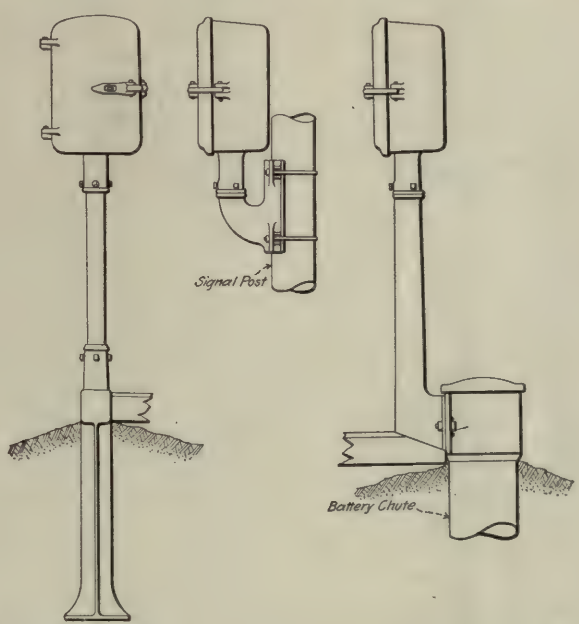
Fig. 3155. Reinforced Cement Relay Box, Post and Foundation. C. F. Massey Company.



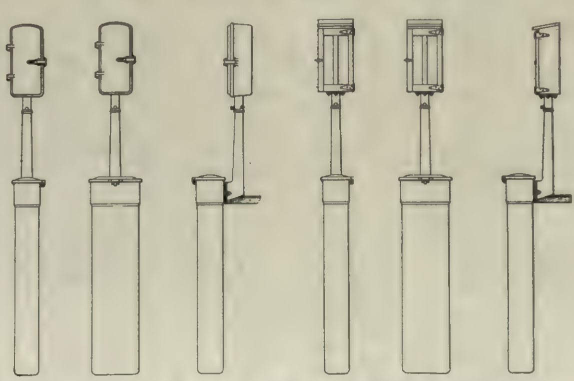
Figs. 3156-3162. Indicator and Relay Boxes Mounted on Cable Posts. The Union Switch & Signal Company.



Figs. 3163-3164. Relay Boxes and Cable Posts Mounted on Battery Chutes. General Railway Signal Company.



Figs. 3165-3166. Iron Relay Boxes and Posts. The Union Switch & Signal Company.



Figs. 3167-3172. Relay Boxes and Stub Posts Mounted on Battery Chutes. General Railway Signal Company.

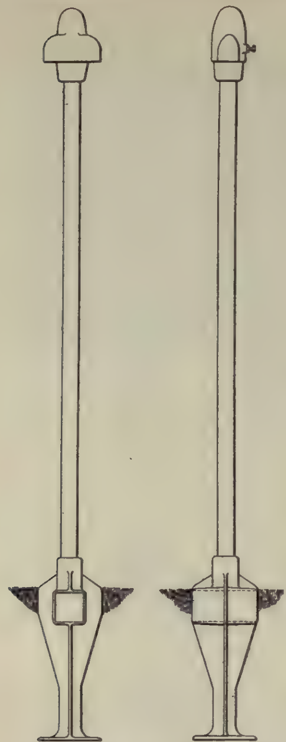


Fig. 3173.

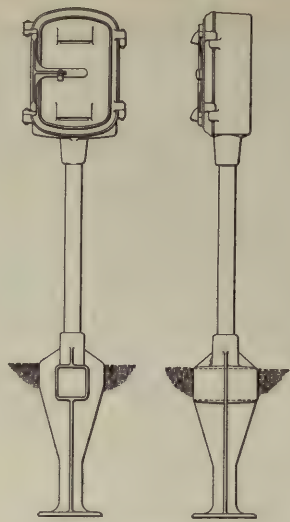


Fig. 3174.

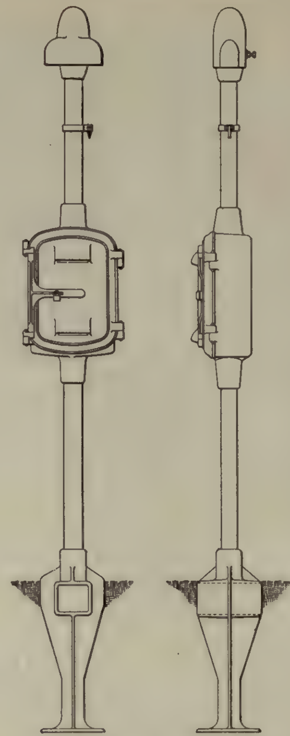


Fig. 3175.

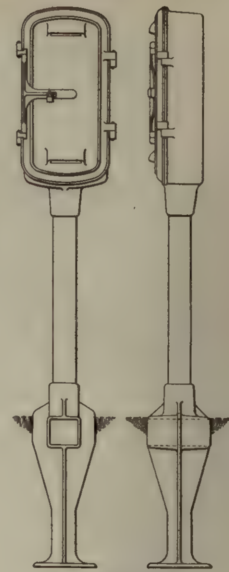


Fig. 3176.

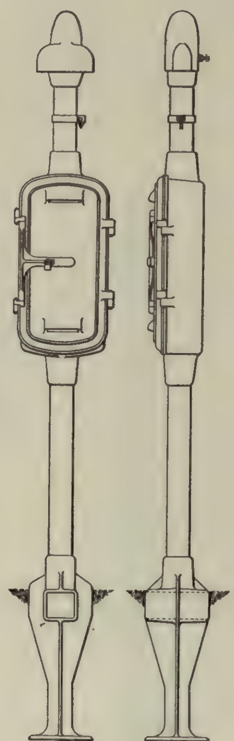


Fig. 3177.

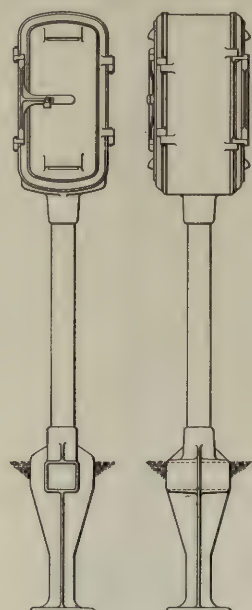


Fig. 3178.

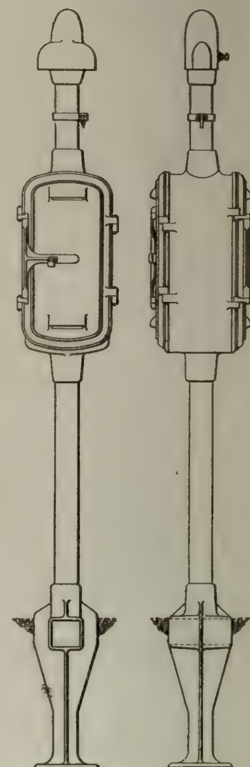


Fig. 3179.

Figs. 3173-3179. Indicator and Relay Boxes Mounted on Iron Posts and Iron Foundations. Union Switch & Signal Company.

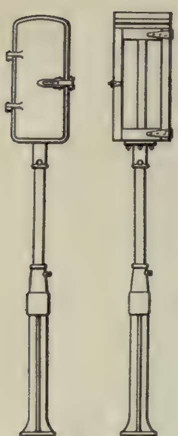


Fig. 3180.

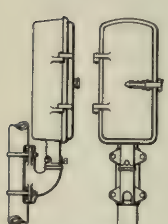


Fig. 3181.

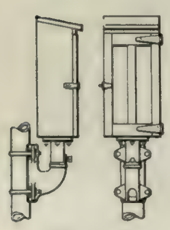


Fig. 3182.

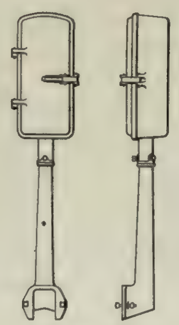


Fig. 3183.

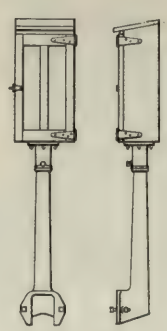
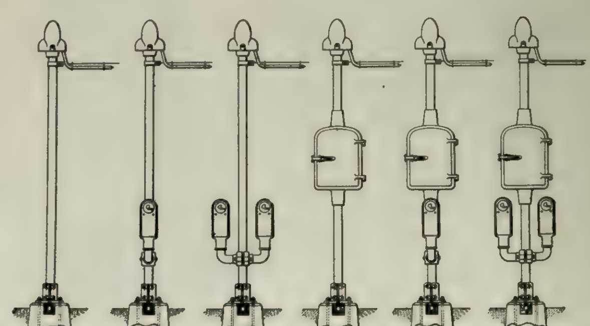
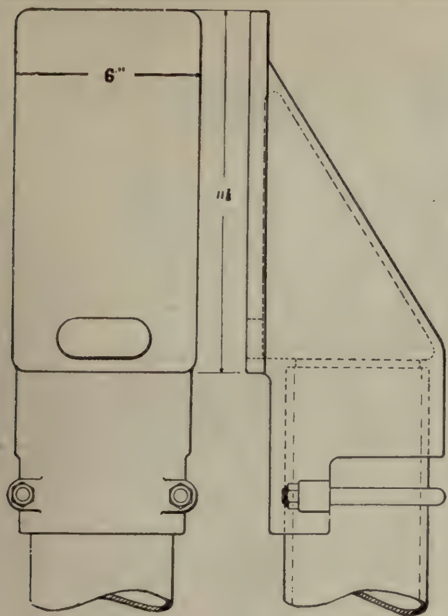


Fig. 3184.

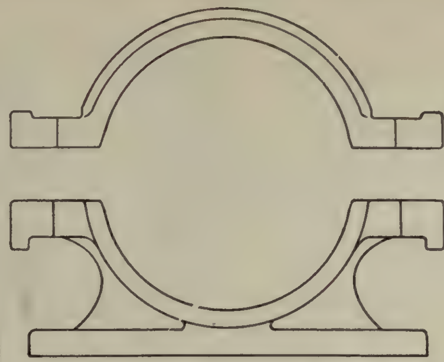
Figs. 3181-3184. Relay Boxes, Pole Fittings, and Attachments and Combinations. General Railway Signal Company.



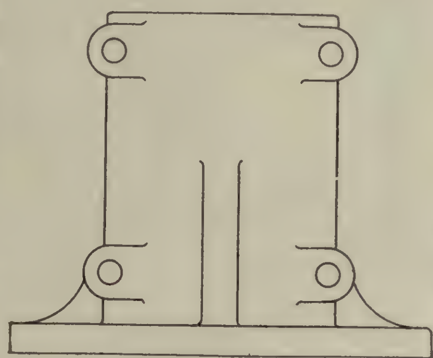
Figs. 3185-3190. Cable Posts, Indicators, and Relay Boxes. General Railway Signal Company.

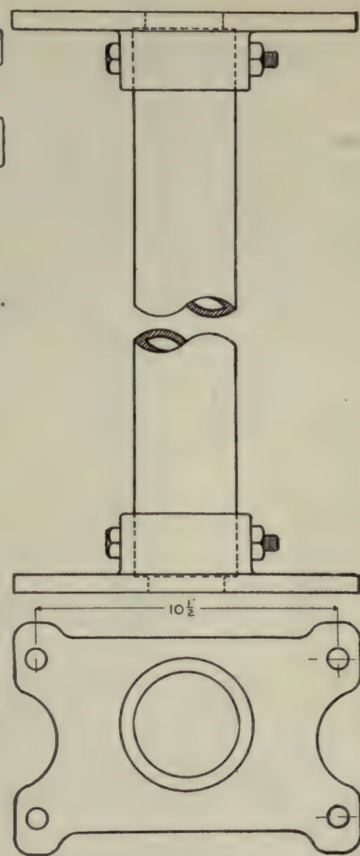


Figs. 3191-3192. Bracket Support for Relay Bell and Indicator.

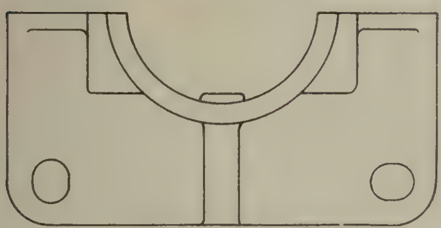


Figs. 3193-3194. Malleable Pole Clamps.



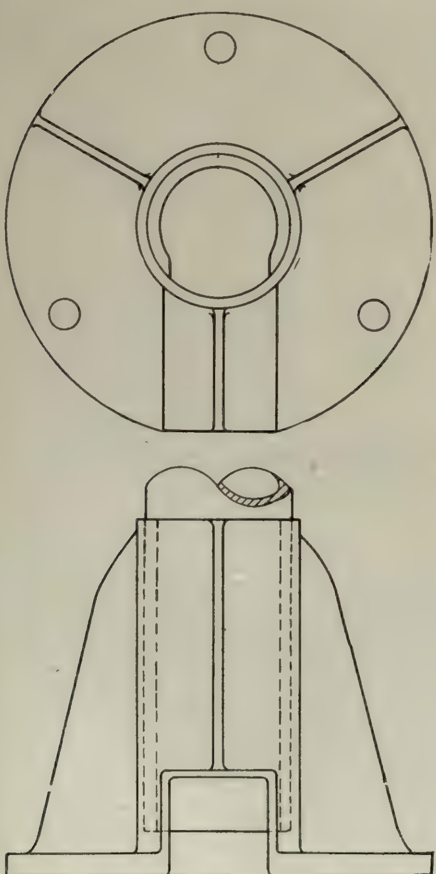


Figs. 3197-3199. Relay Box Post.

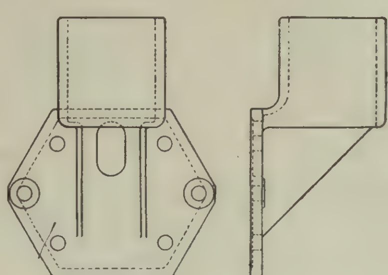


Figs. 3195-3196. Two Piece Base Castings.

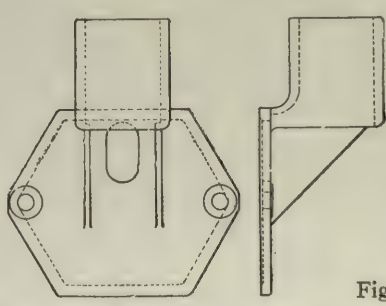
Fig. 3200. Pinnacle.



Figs. 3201-3202. One Piece Base Casting.



Figs. 3203-3204. Pipe Sockets.



Figs. 3205-3206. Pipe Sockets.

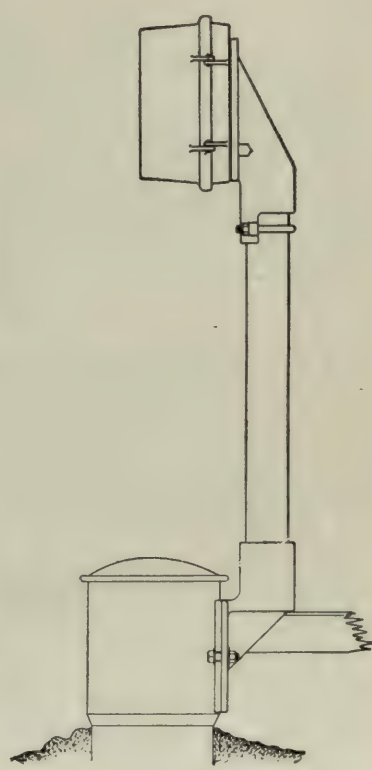


Fig. 3207. Assembly for Battery Chute and Relay Box.

Figs. 3191-3207. Relay Box and Cable and Signal Post Fittings. Railroad Supply Company.

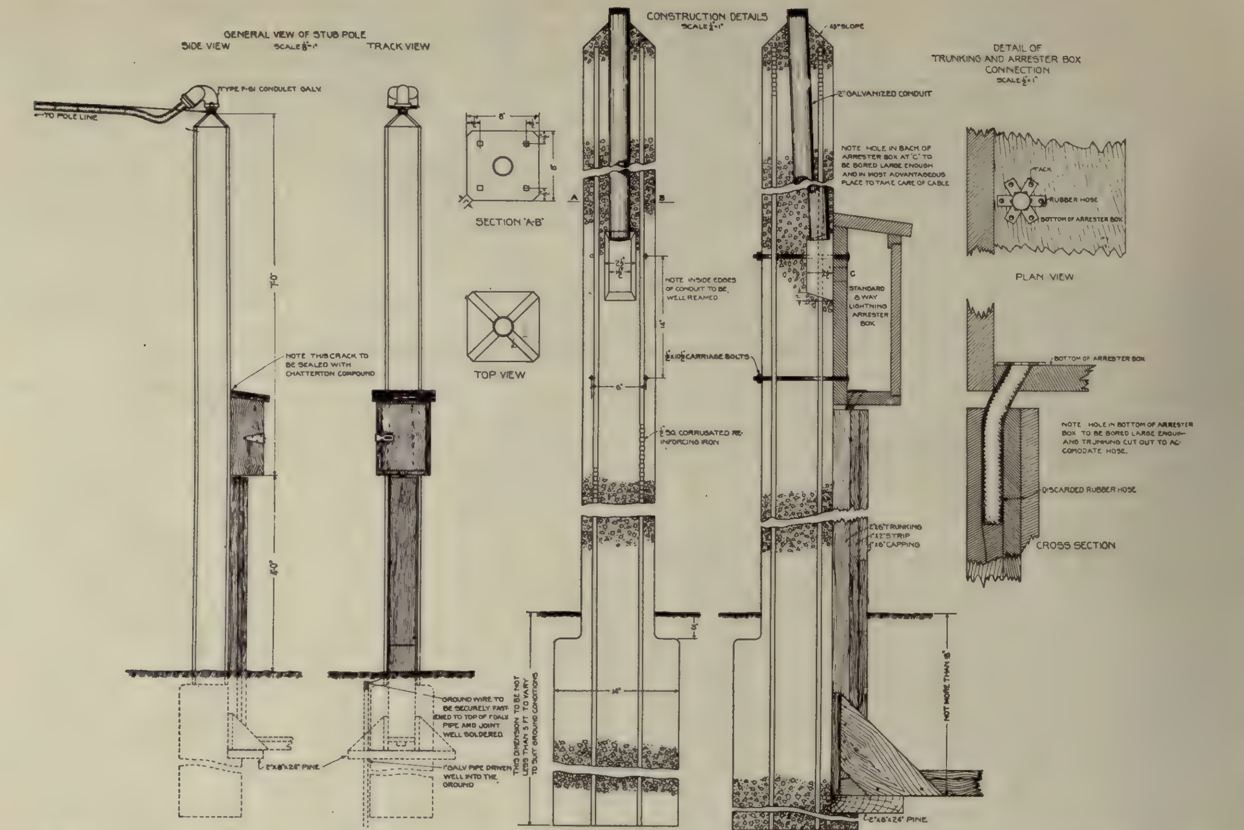


Fig. 3208-3215. Relay Box, Stub Pole, Foundation, Trunking Connections and Details. Atchison, Topeka & Santa Fe.

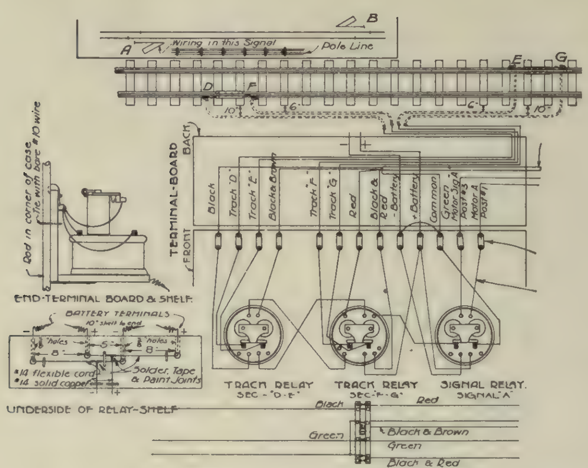


Fig. 3216. Case Wiring. Staggered Home Signals. Oregon Short Line.

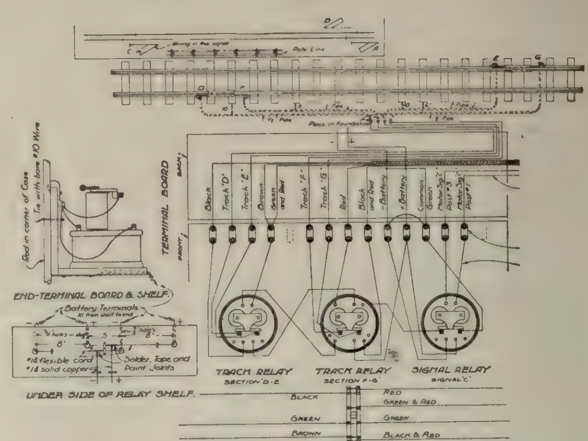
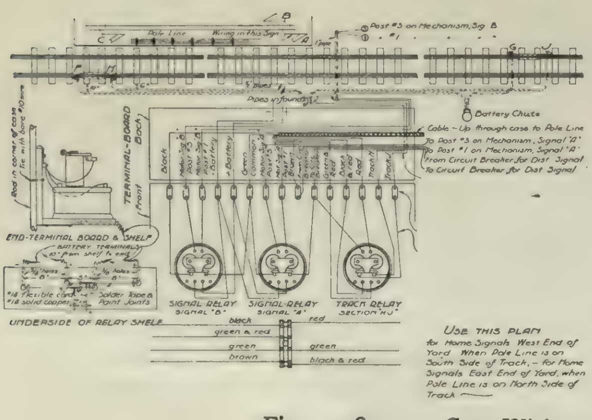
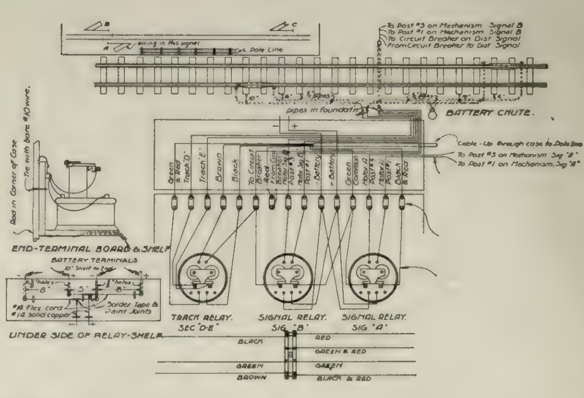


Fig. 3217. Case Wiring. Distant Signals. Oregon Short Line.





Figs. 3218-3219. Case Wiring. Home Signals. Oregon Short Line.

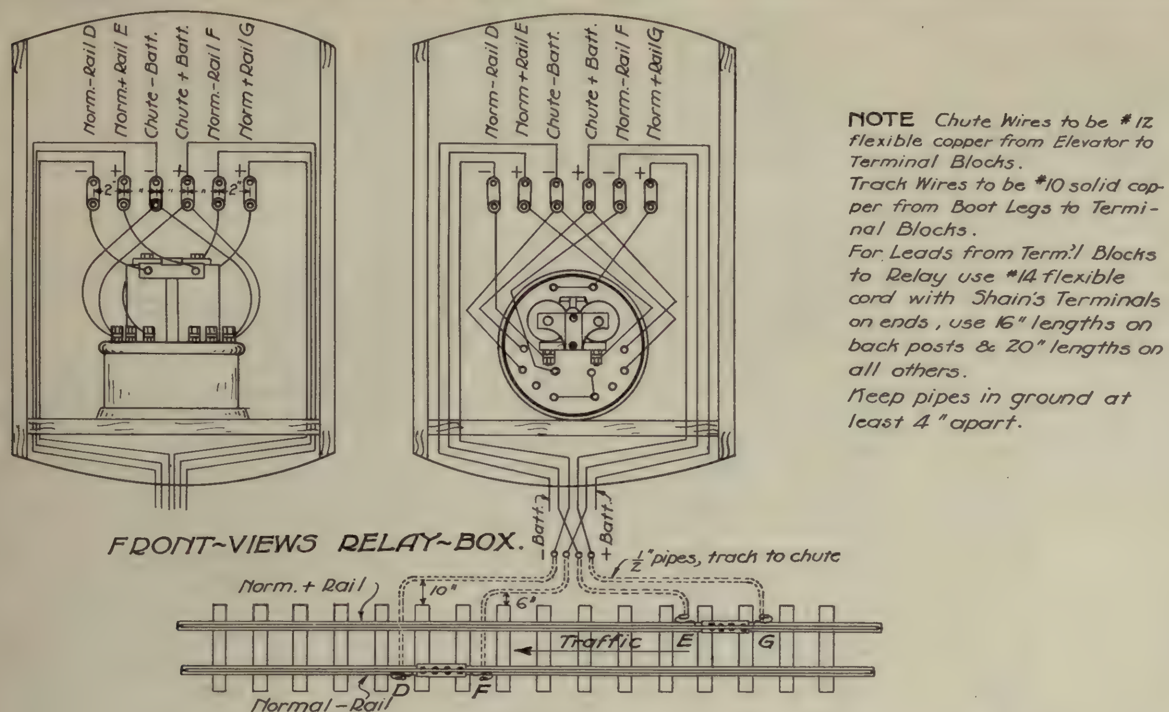


Fig. 3220. Case Wiring, Double Track Polarized Relayed Section. Oregon Short Line.

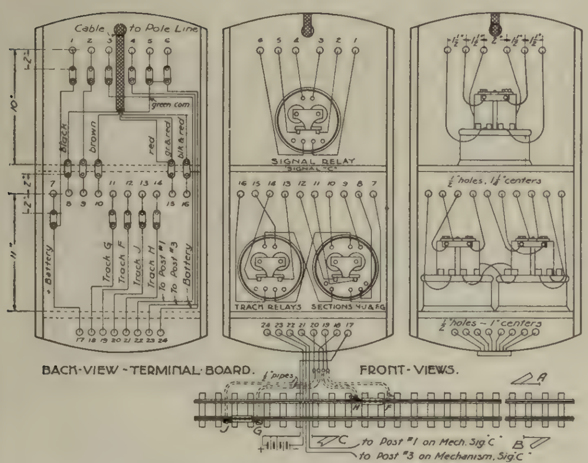


Fig. 3221. Case Wiring. Relay Box for Distant Signal. Oregon Short Line.

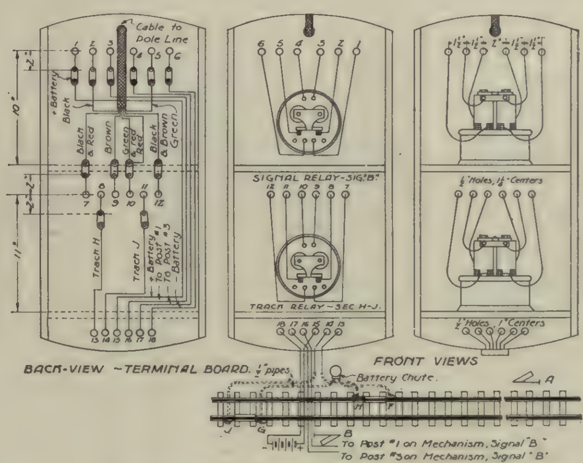


Fig. 3222. Case Wiring. Relay Box for Staggered Home Signals. Oregon Short Line.

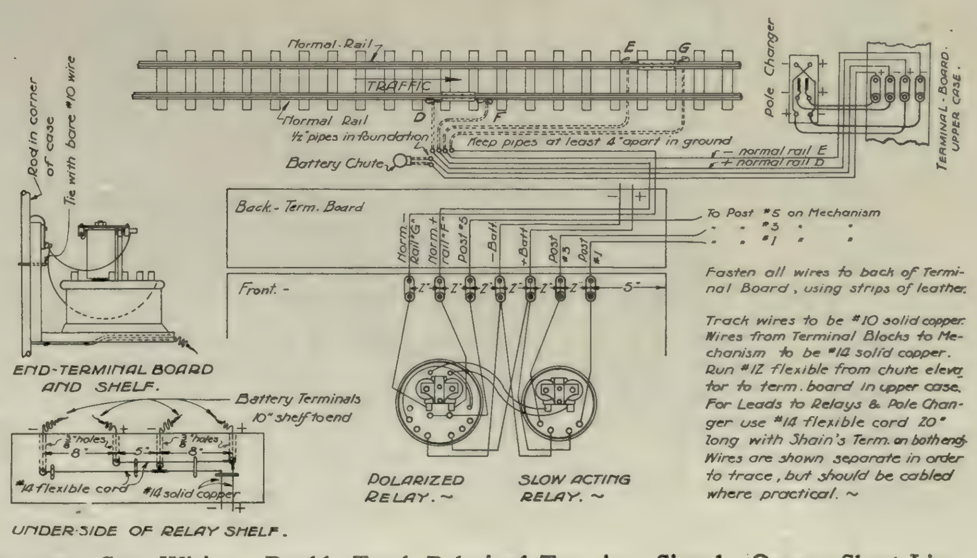
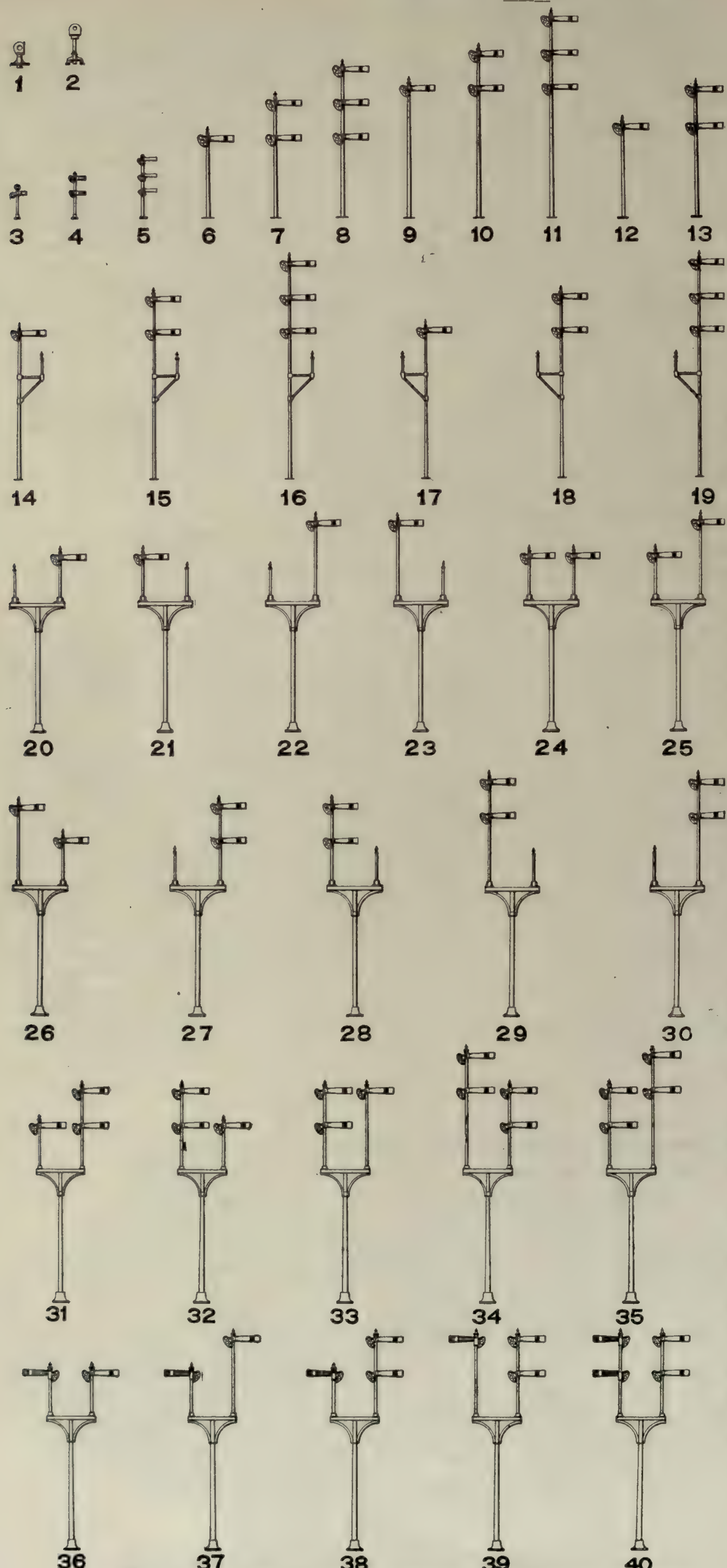


Fig. 3223. Case Wiring. Double Track Polarized Two-Arm Signal. Oregon Short Line.

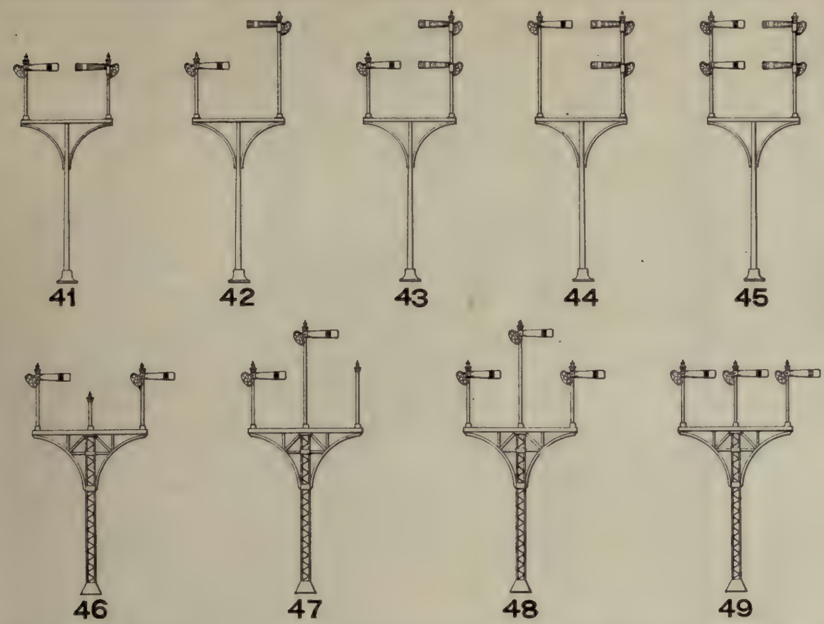
SIGNALS AND FITTINGS



Figs. 3224-3263. Typical Arrangements of Signals.

Names of Parts; Figs. 3224-3263.

1 *Low Pot Signal*
2 *High Pot Signal*
3 *One-Arm Dwarf Signal*
4 *Two-Arm Dwarf Signal*
5 *Three-Arm Dwarf Signal*
6 *One-Arm Bridge Signal*
7 *Two-Arm Bridge Signal*
8 *Three-Arm Bridge Signal*
9 *One-Arm Ground Signal*
10 *Two-Arm Ground Signal*
11 *Three-Arm Ground Signal*
12 *One-Arm' Elevated Railroad Signal*
13 *Two-Arm Elevated Railroad Signal*
14 *One-Arm Cantilever Signal*
15 *Two-Arm Cantilever Signal*
16 *Three-Arm Cantilever Signal*
17 *One-Arm Cantilever Signal*
18 *Two-Arm Cantilever Signal*
19 *Three-Arm Cantilever Signal*
20 *One-Arm Bracket Signal*
21 *One-Arm Bracket Signal*
22 *One-Arm Bracket Signal with High Bracket Mast*
23 *One-Arm Bracket Signal with High Bracket Mast*
24 *Two-Arm Bracket Signal*
25 *Two-Arm Bracket Signal, One High and one Low Bracket Mast*
26 *Two-Arm Bracket Signal, One High and One Low Bracket Mast.*
27 *Two-Arm Bracket Signal*
28 *Two-Arm Bracket Signal*
29 *Two-Arm Bracket Signal, with High Bracket Mast*
30 *Two-Arm Bracket Signal, with High Bracket Mast*
31 *Three-Arm Bracket Signal*
32 *Three-Arm Bracket Signal*
33 *Three-Arm Bracket Signal, with One High Bracket Mast*
34 *Four-Arm Bracket Signal, with One High Bracket Mast*
35 *Four-Arm Bracket Signal, with One High Bracket Mast*
36 *Two-Arm Bracket Signal*
37 *Two-Arm Bracket Signal, with One High Bracket Mast*
38 *Three-Arm Bracket Signal*
39 *Three-Arm Bracket Signal, with One High Bracket Mast*
40 *Four-Arm Bracket Signal*



41 *Two-Arm Bracket Signal*

42 *Two-Arm Bracket Signal, with One High Bracket Mast*

43 *Three Arm Bracket Signal*

44 *Three-Arm Bracket Signal, with One High Bracket Mast*

45 *Four-Arm Bracket Signal*

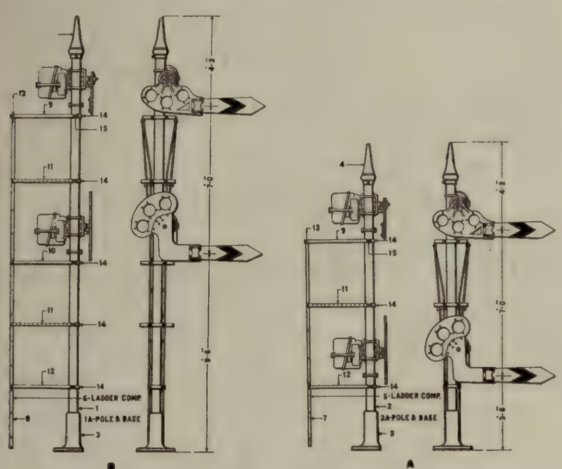
46 *Two-Arm, Three-Bracket Mast. Lattice Post Bracket Signal*

47 *Two-Arm, Three-Bracket Mast, Lattice Post Bracket Signal*

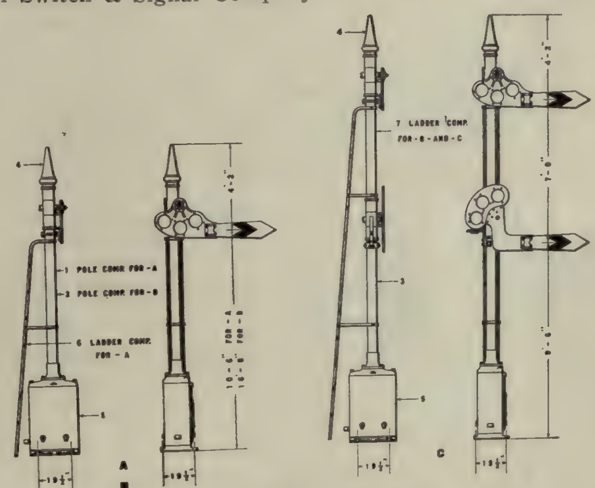
48 *Three-Arm, Three-Bracket Mast. Lattice Post Bracket Signal*

49 *Three-Arm, Three-Bracket Mast, Lattice Post Bracket Signal*

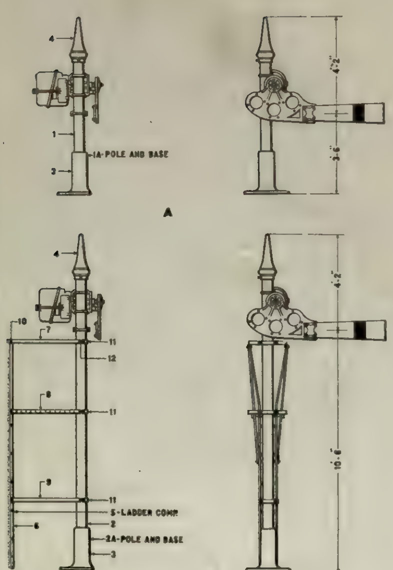
Figs. 3264-3273. Typical Arrangements of Signals. Union Switch & Signal Company.



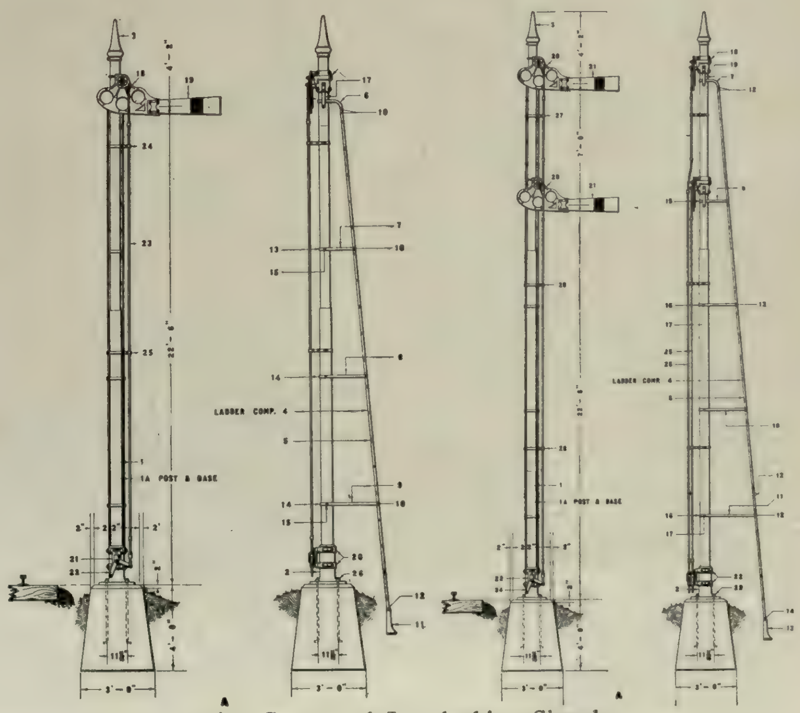
Bridge Signals.



Base of Mast Signals.

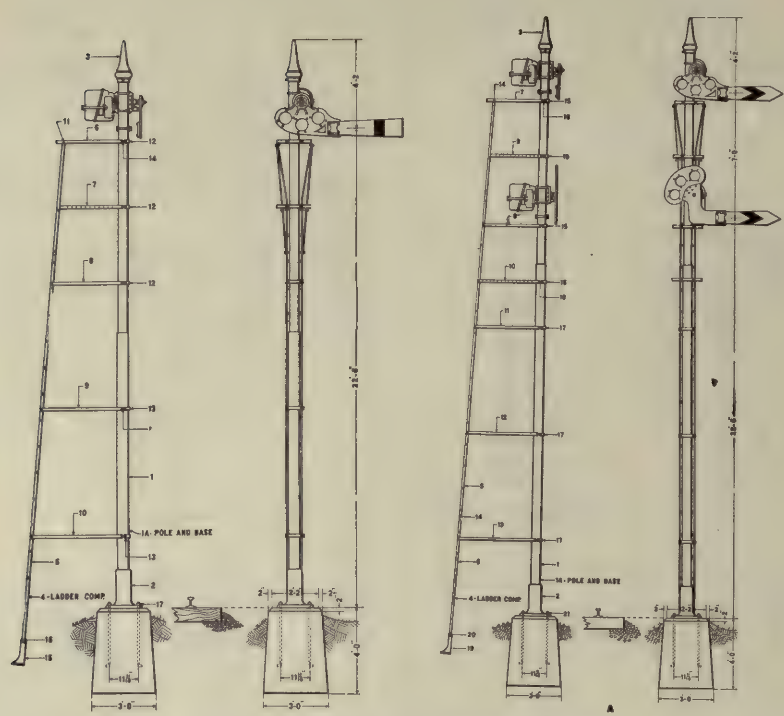


Bracket Signals.

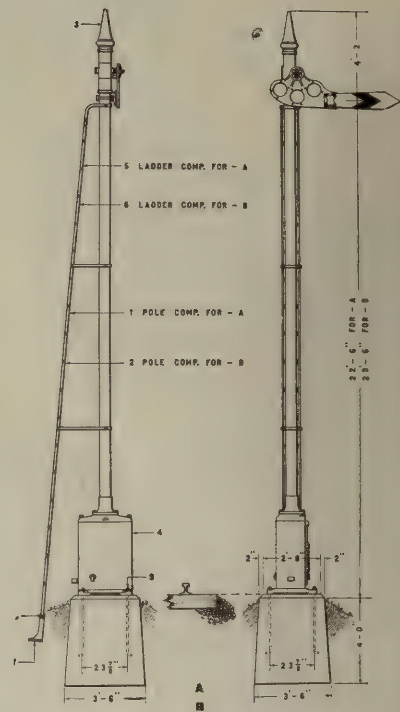


Pipe Connected Interlocking Signals.

Figs. 3274-3289. Typical Arrangements of Signals. General Railway Signal Company.

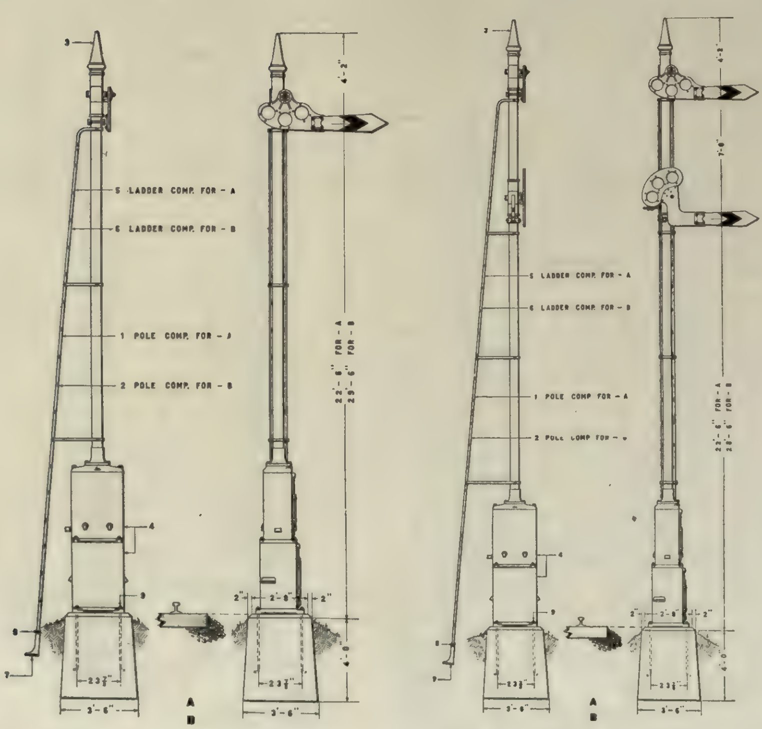


Model "2A" Direct Connected Signals.

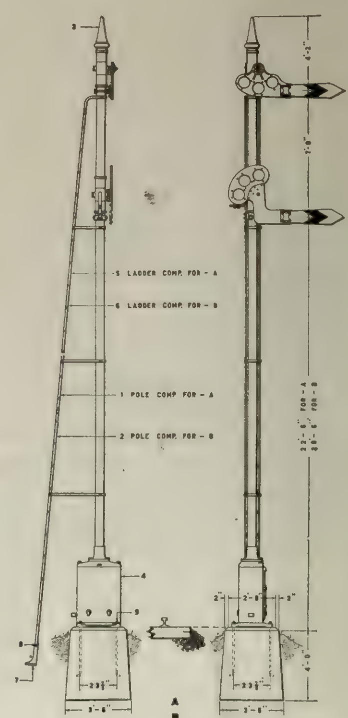


Model "2A" Base of Mast Signal.

Figs. 3290-3295. Typical Arrangements and Assemblies of Signals. General Railway Signal Company.

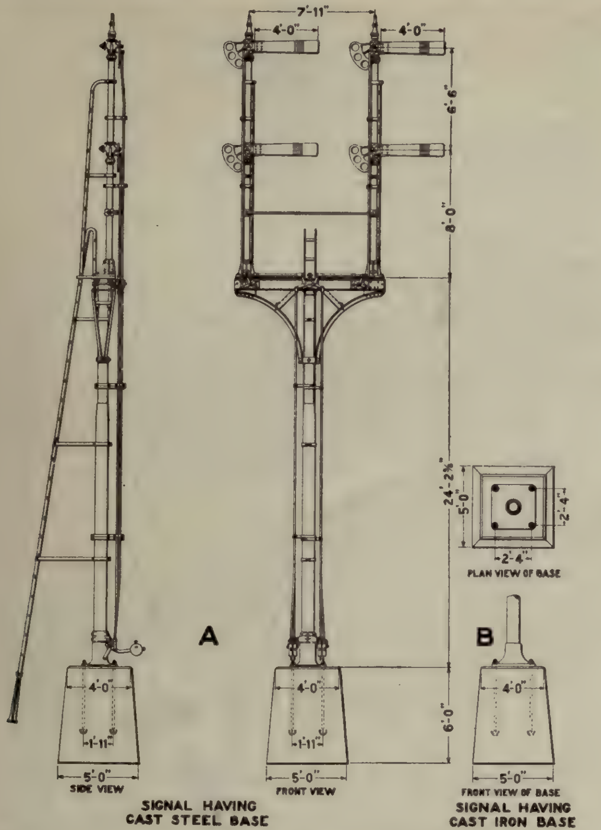


Model "2A" Signals with Base of Mast Mechanism and Battery Case.

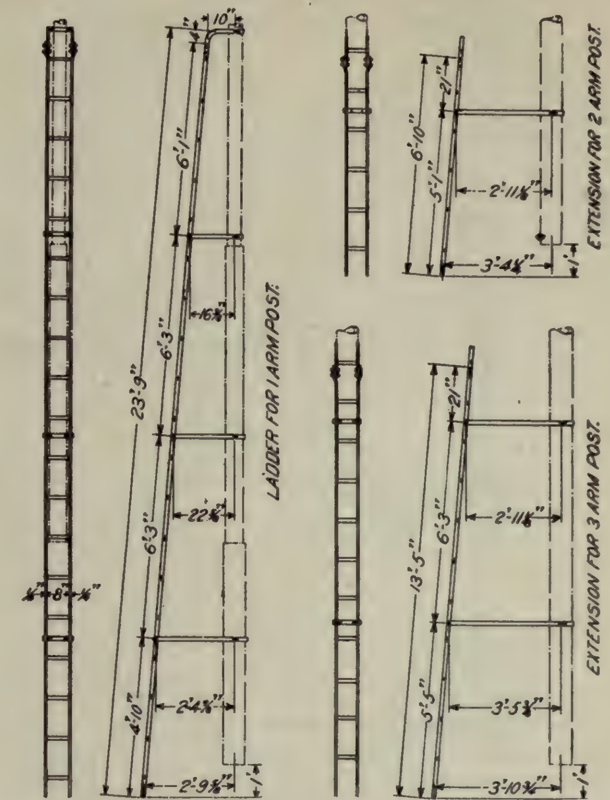


Model "2A" Base of Mast Signal.

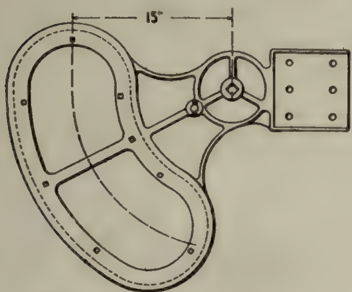
Figs. 3296-3301. Typical Arrangements and Assemblies of Signals. General Railway Signal Company.



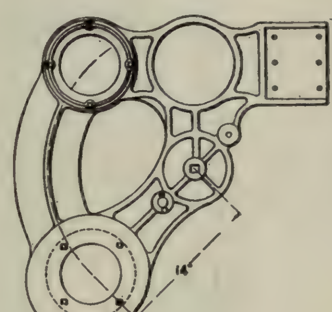
Figs. 3302-3305. Four-Arm Mechanical Bracket Signal. Union Switch & Signal Company.



Figs. 3306-3311. R. S. A. Standard Ladders for Pipe Signal Posts.



Figs. 3312-3313.
Types of Two-Light Semaphore Castings.



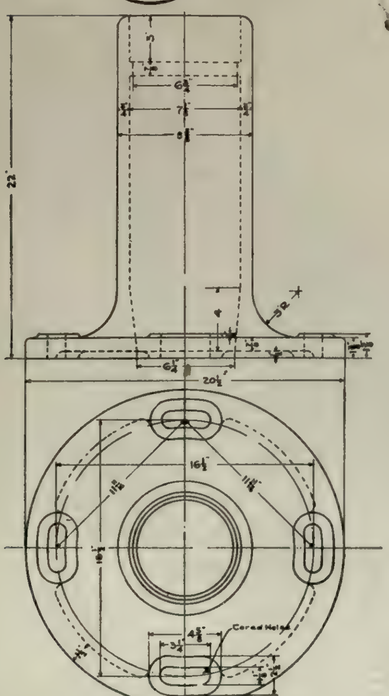


Fig. 3314. R. S. A. Standard Base for Six-Inch Signal Post.

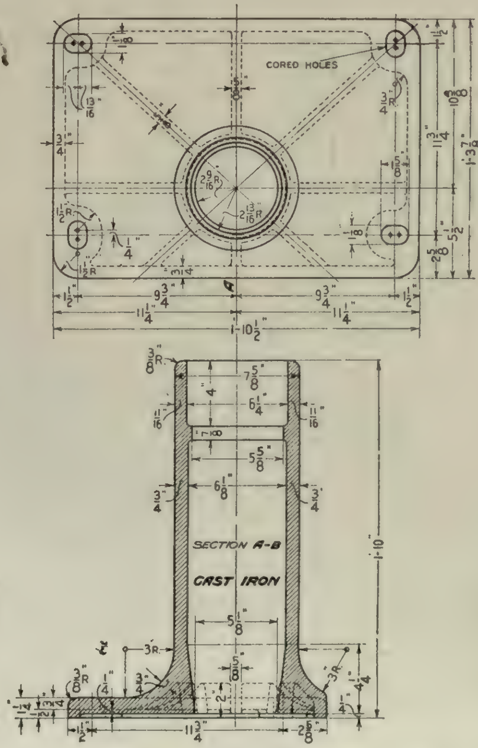
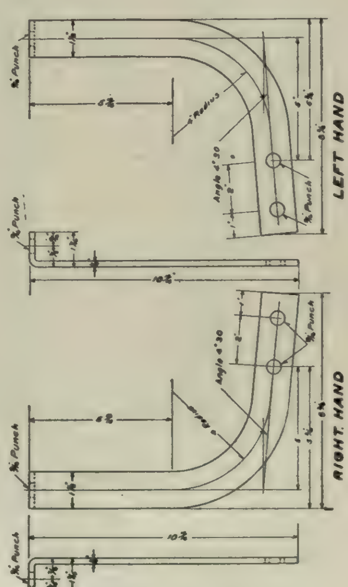


Fig. 3315. R. S. A. Standard Base for Bridge Signal Masts.



Figs. 3316-3318. R. S. A. Standard Top of Ladder Details.

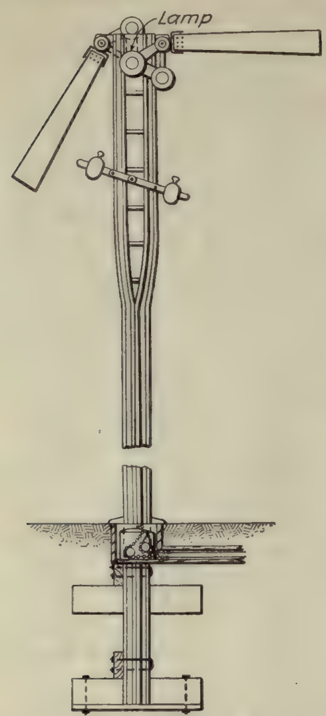
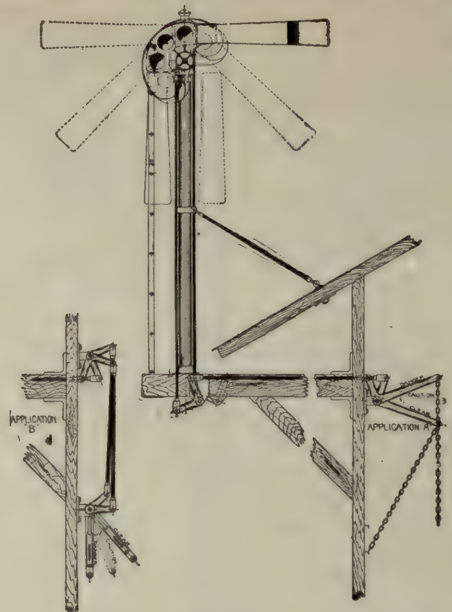


Fig. 3319. Double, Two-Position Train Order Signal; Post Made of Rails, Pipe Connected, Using Standard Semaphore Castings for Both Arms. Chicago & North-Western.



Figs. 3320-3321. Double, Three-Position, 90-Deg. Train Order Signal; Iron Pipe Post, Pipe Connected, with "Universal" Semaphore Casting.

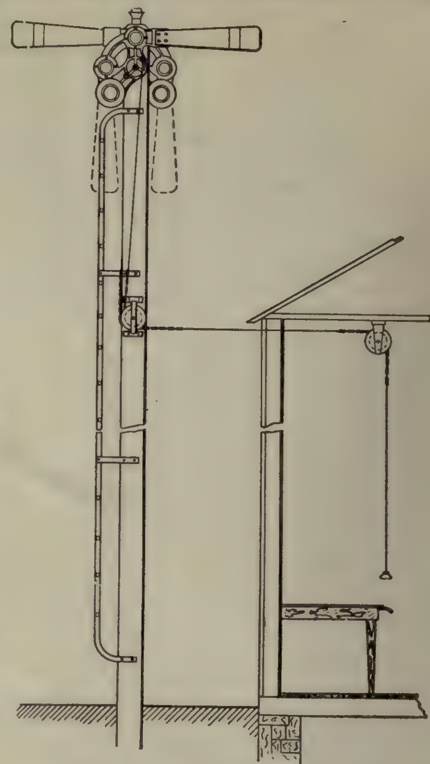
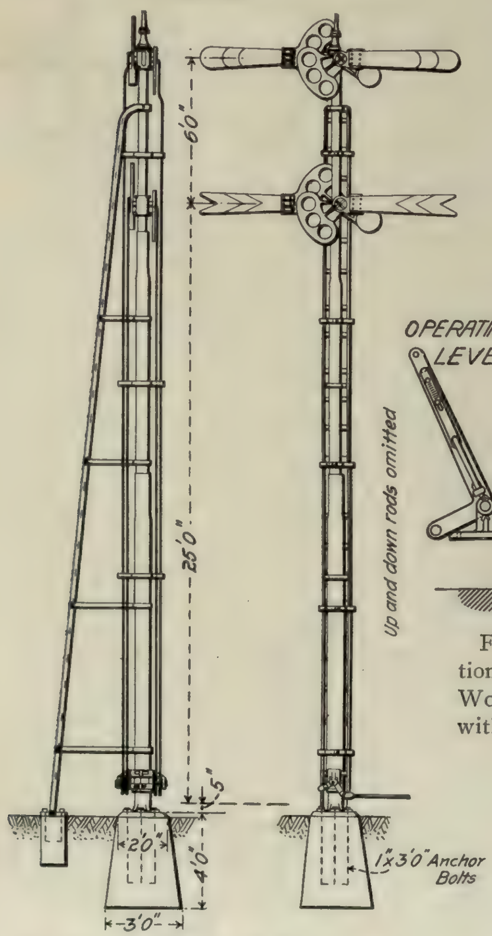
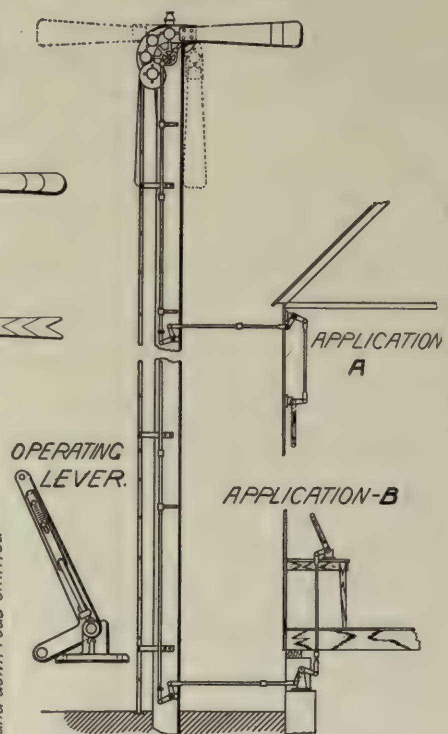


Fig. 3322. Double, Two-Position, 90-Deg. Train Order Signal; Wooden Post, Wire Connected.



Figs. 3323-3324. **Two-Arm** Double, Two-Position Train Order Signal; Iron Pipe Post, Pipe Connected. New York Central & Hudson River.



Figs. 3325-3326. Double, Two-Position, 90-Deg. Train Order Signal, Wooden Post, Pipe Connected, with "Universal" Semaphore Casting.

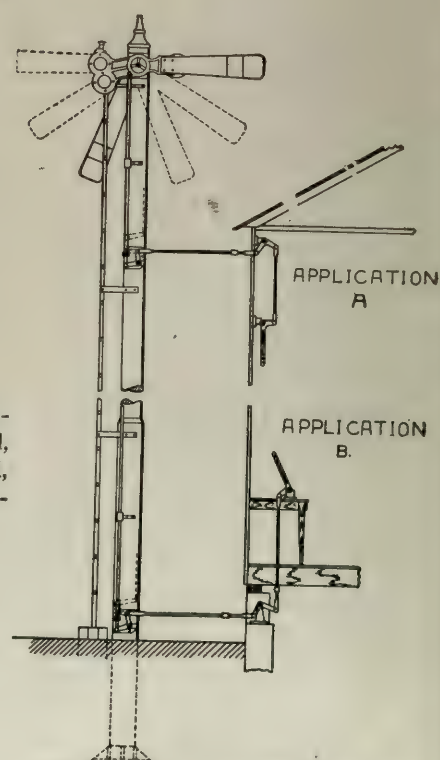


Fig. 3327. Double, Three-Position, 75-Deg. Train Order Signal; Iron Pipe Post, Pipe Connected.

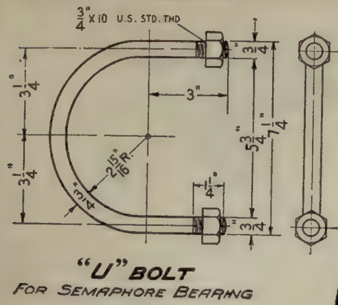


Fig. 3328. "U" Bolt for Semaphore Bearing.

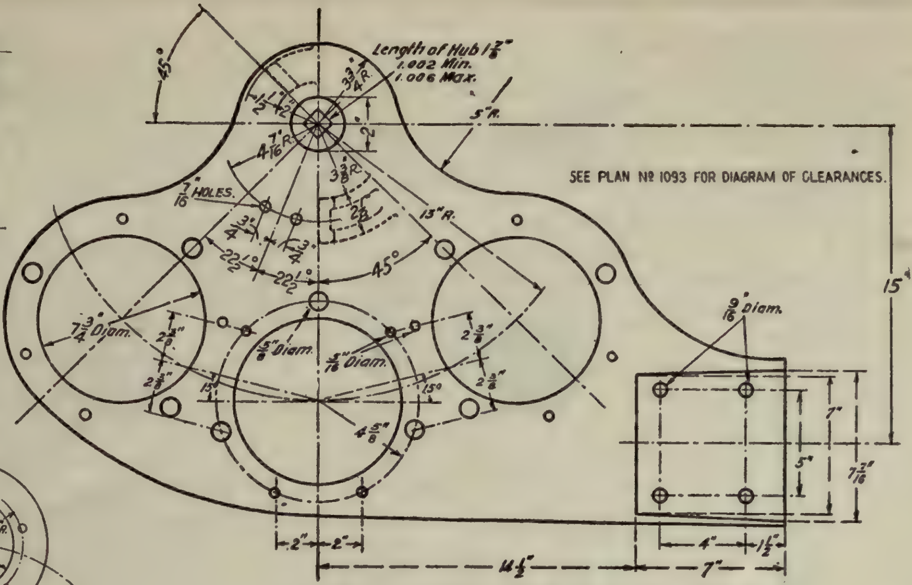


Fig. 3329. Semaphore Spectacle (Design A).

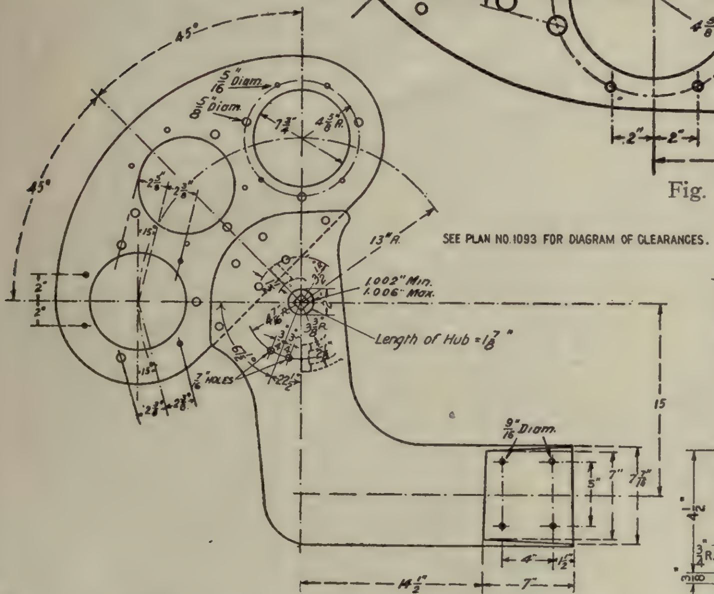
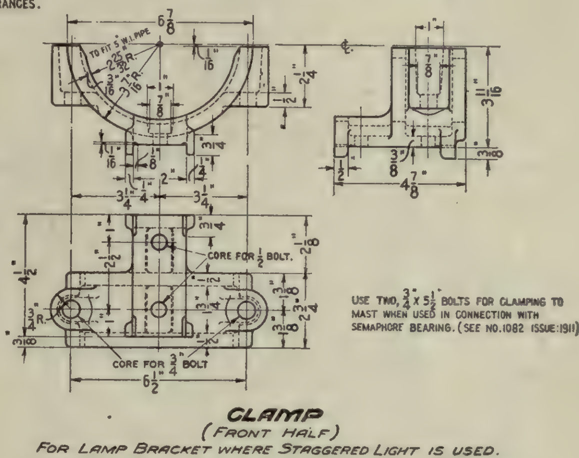


Fig. 3330. Semaphore Spectacle (Design B).



Figs. 3331-3333. Clamp for Semaphore Bearing.

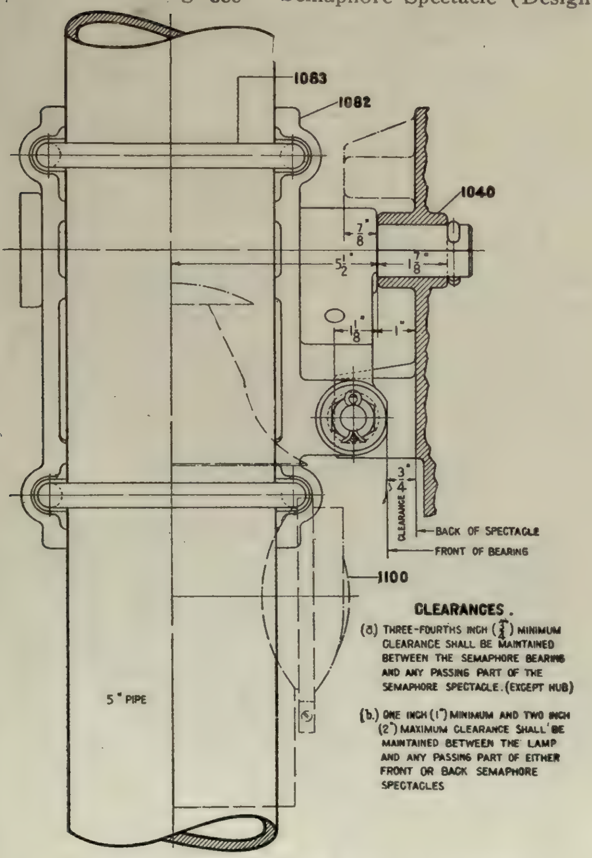
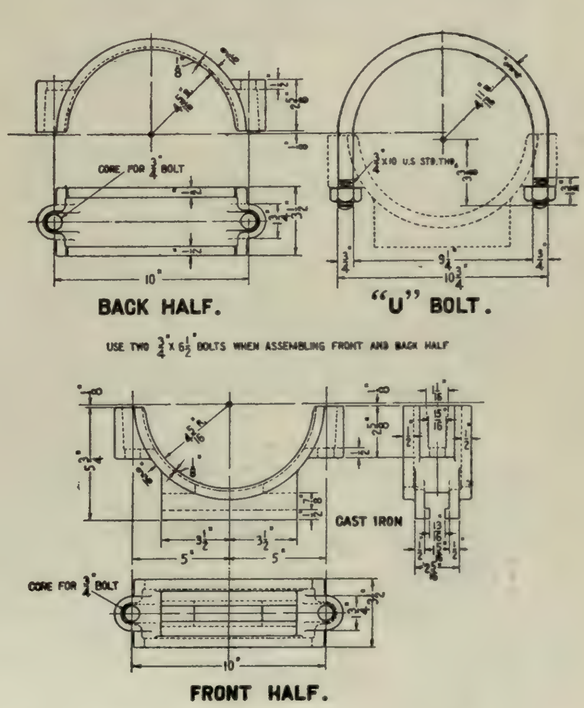
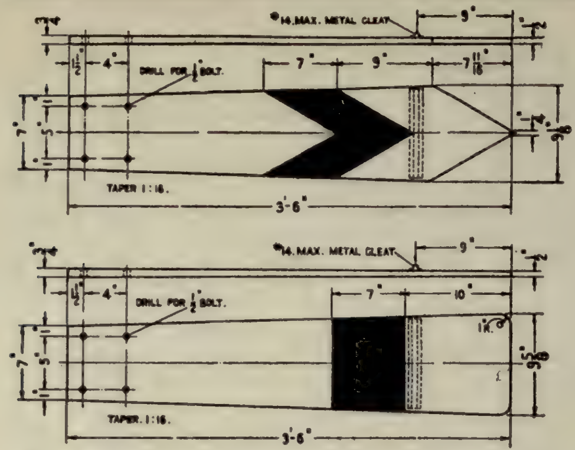


Fig. 3334. Diagram of Spectacle Clearance.



Figs. 3335-3340. Clamp for Base of Ground Signal Masts.

Figs. 3328-3340. Railway Signal Association Standards.



Figs. 3341-3342. Blades for Upper Quadrant Signals.

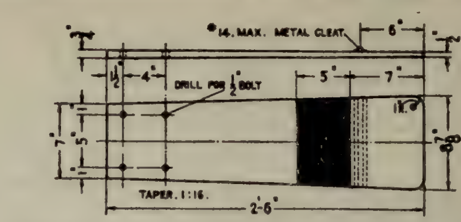
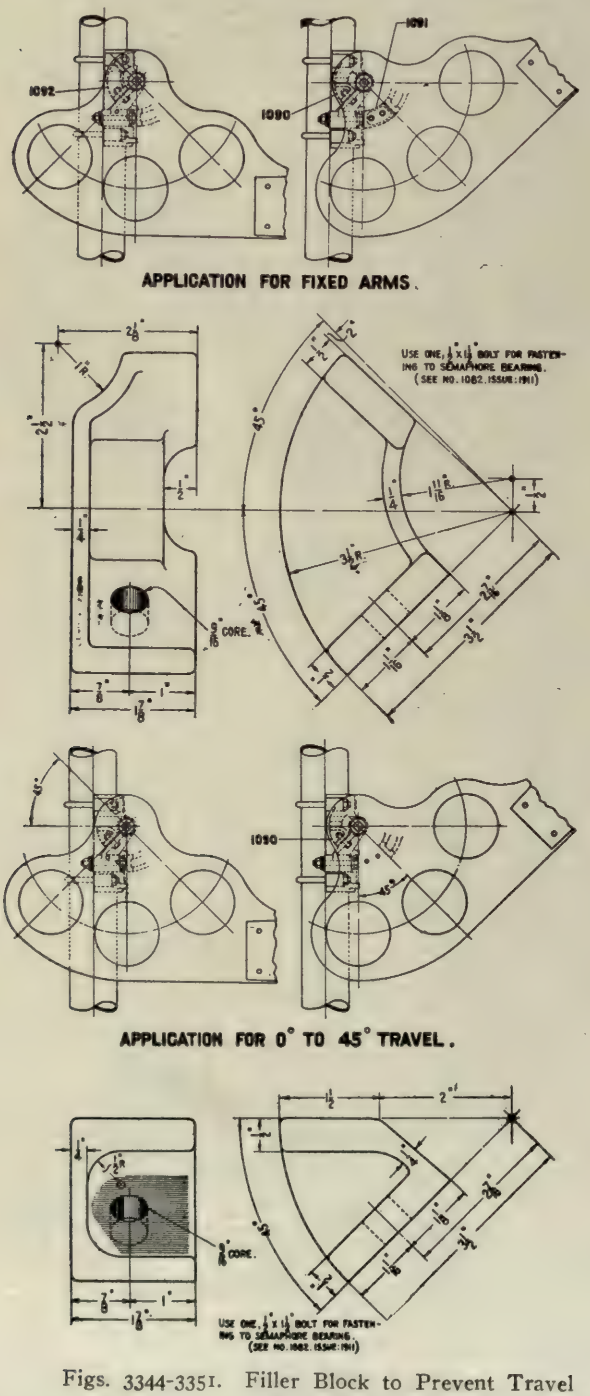
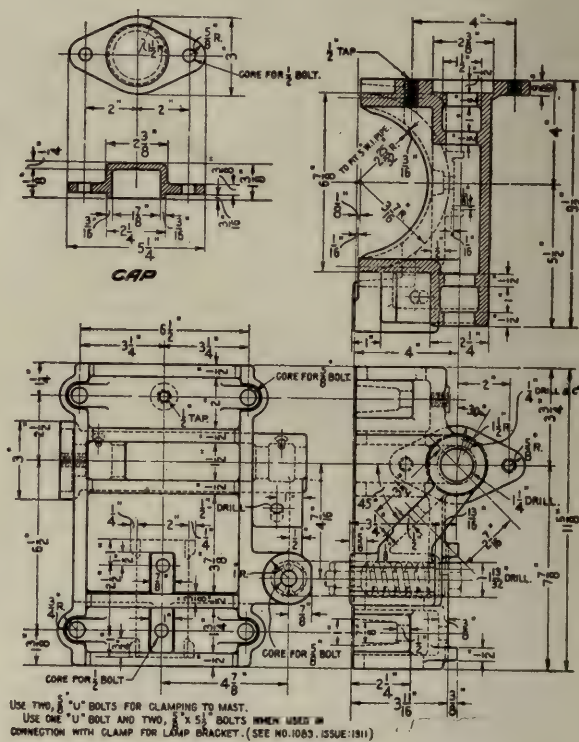


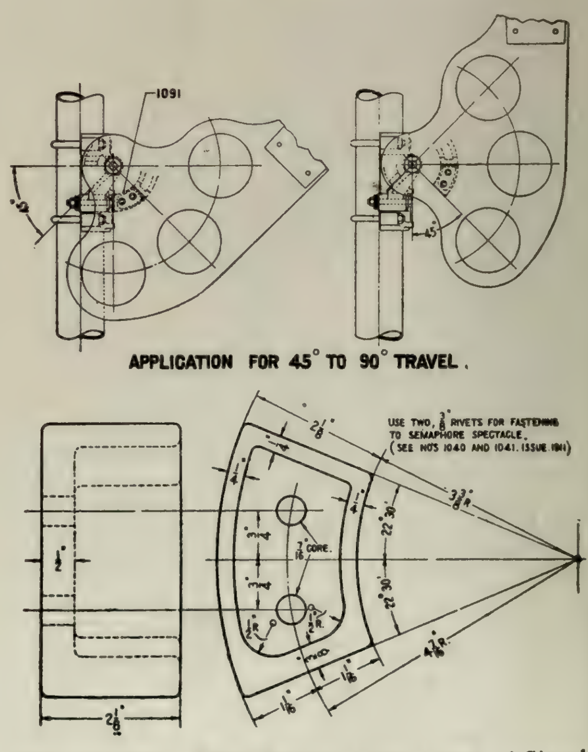
Fig. 3343. Blade for Upper Quadrant Signal.



Figs. 3344-3351. Filler Block to Prevent Travel of Signal Arm.

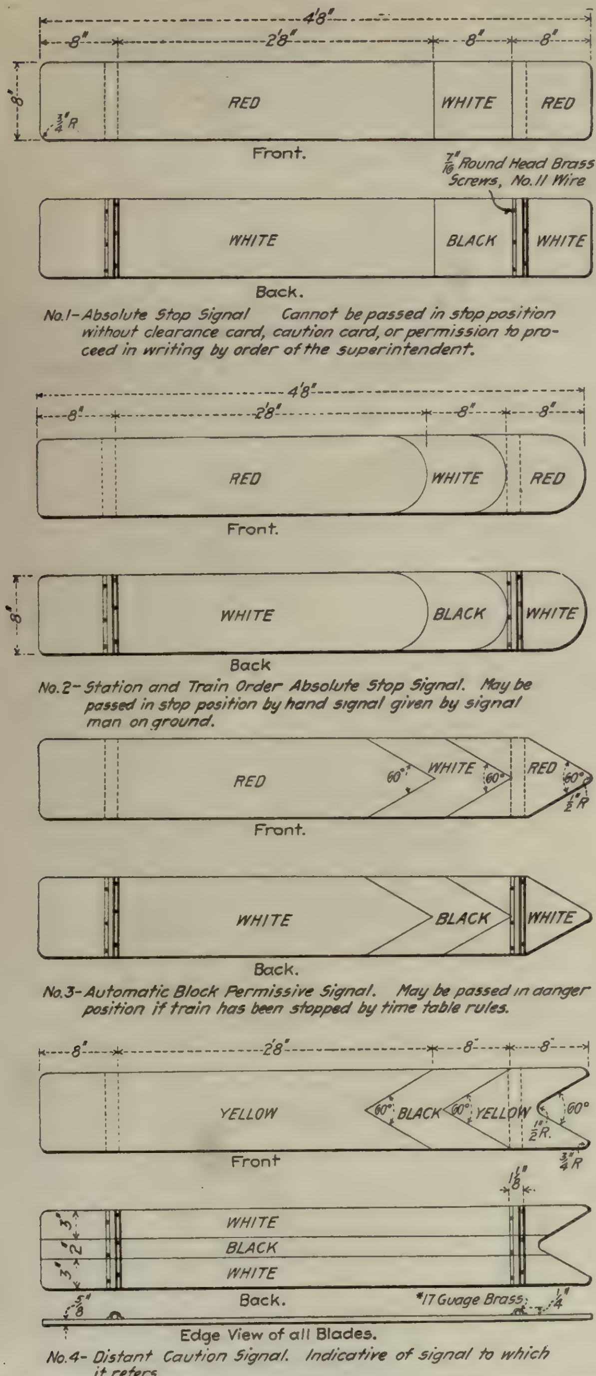


Figs. 3352-3356. Semaphore Bearing.

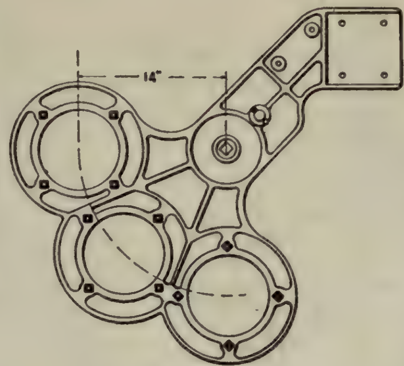


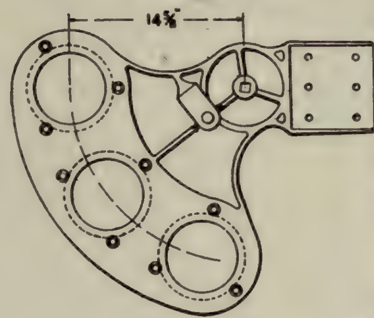
Figs. 3357-3360. Filler Block to Limit Travel of Signal Arms.

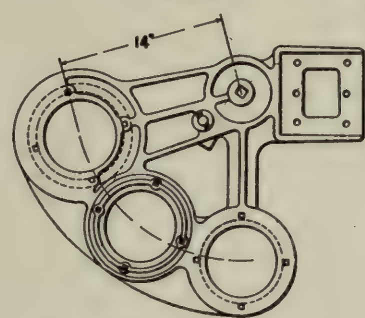
Figs. 3341-3360. Railway Signal Association Standards.

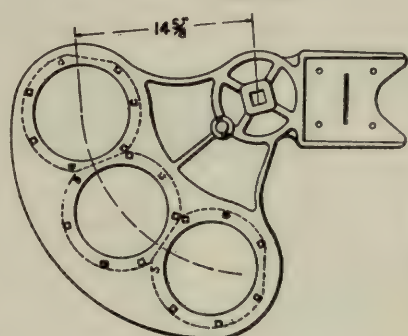


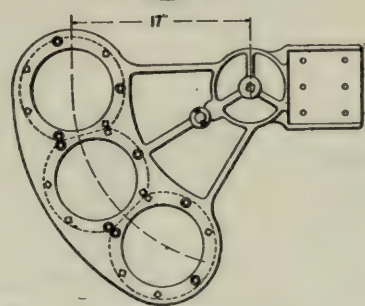
Figs. 3361-3369. Semaphore Blades. New York, New Haven & Hartford.

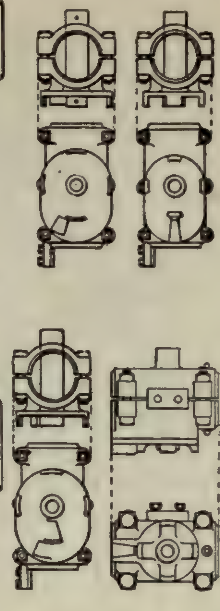




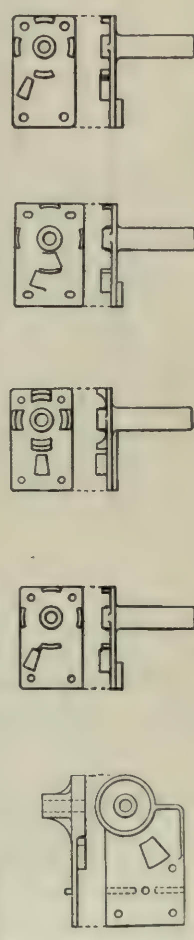




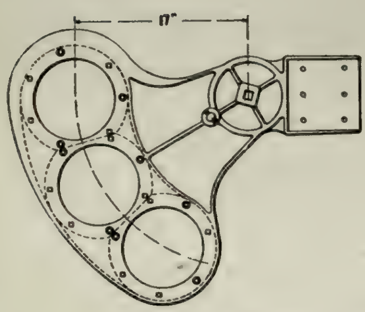


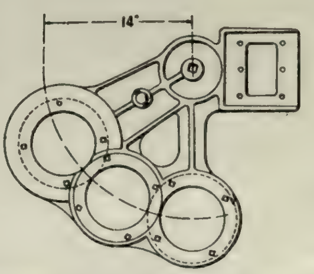


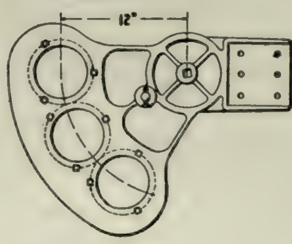
Figs. 3378-3385. Types of Semaphore Bearings for Iron Pipe Post Outside Connected Signals.



Figs. 3386-3395. Types of Semaphore Bearings for Wooden Signal Posts.







Figs. 3370-3377. Types of Three-Light Semaphore Castings.

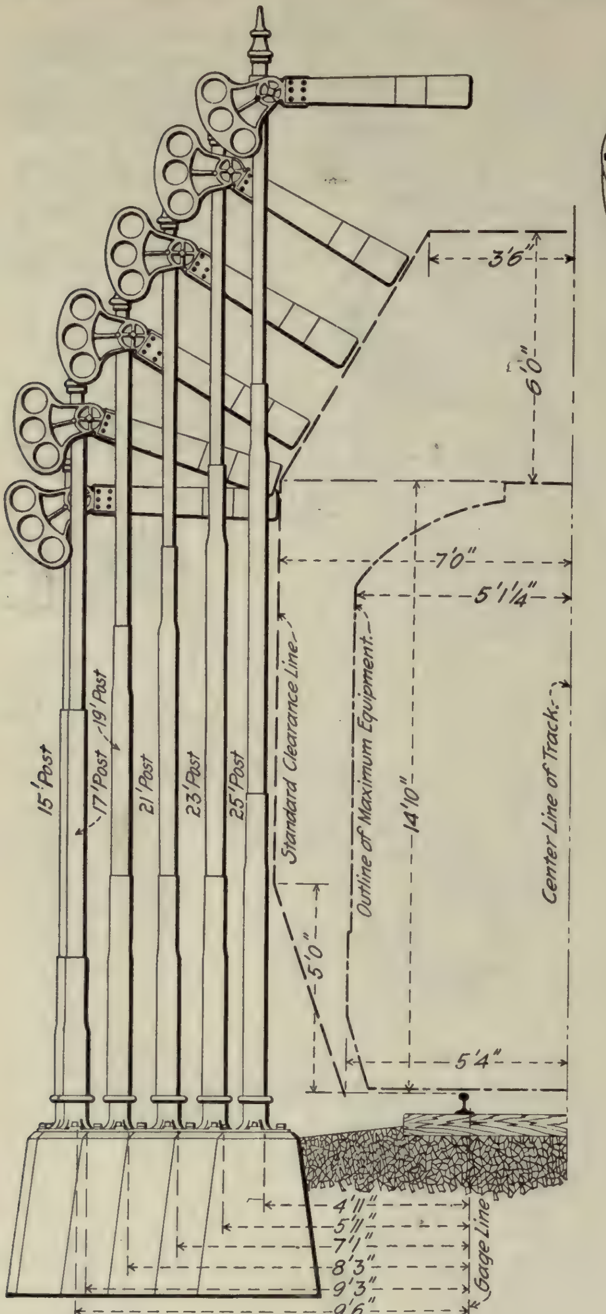
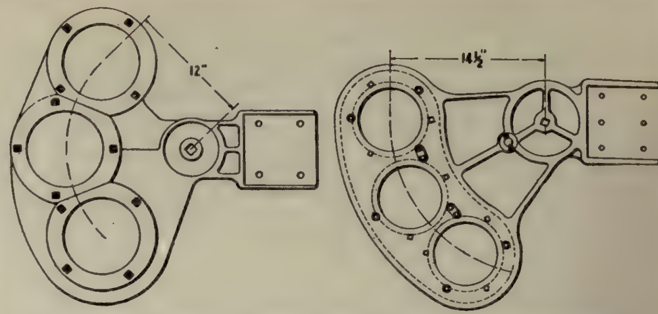
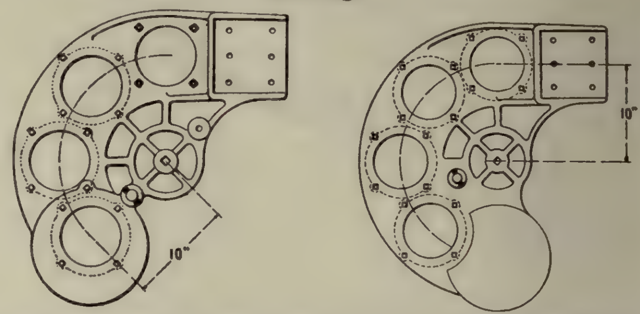


Fig. 3396. Standard Clearance Diagram for Semaphore Signals. New York Central & Hudson River.



Figs. 3397-3398. Types of Three-Light Semaphore Castings.



Figs. 3399-3400. Two Types of "Universal" Semaphore Castings. Four Openings for Roundels are Provided, So That the Lantern May be Placed Either on Top of the Post or on One Side.

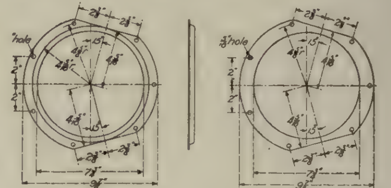
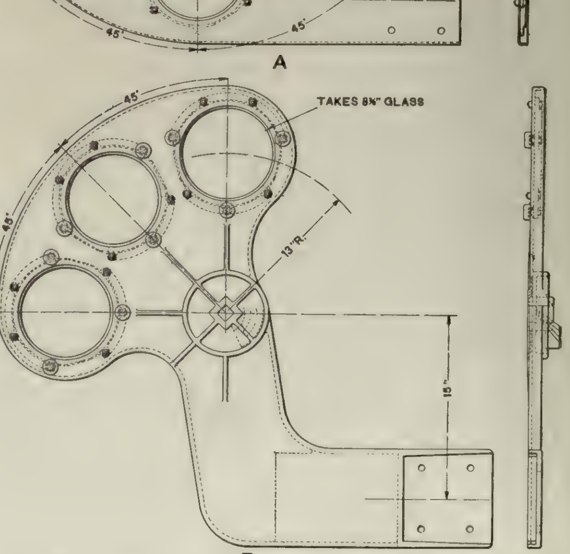


Fig. 3402. R. S. A. Standard Spectacle Rings.



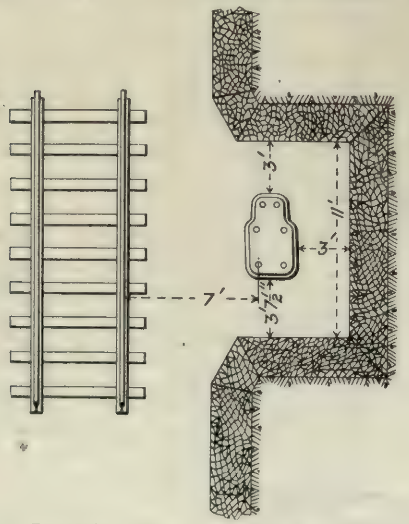
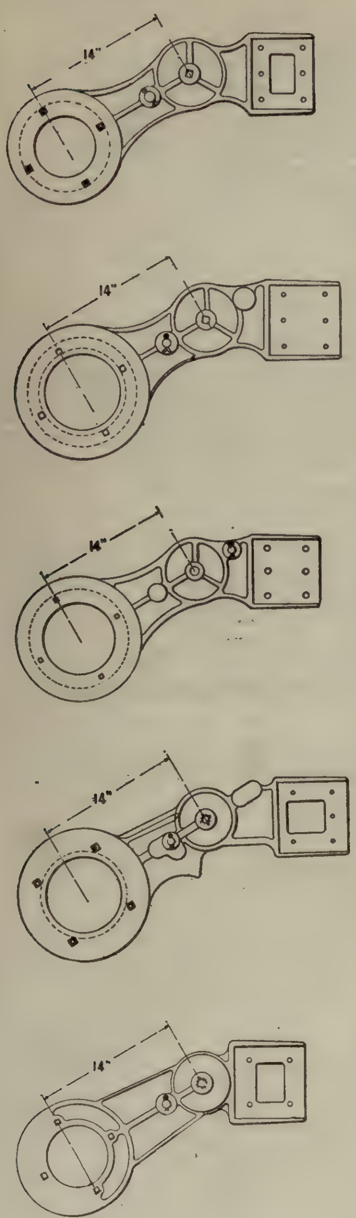
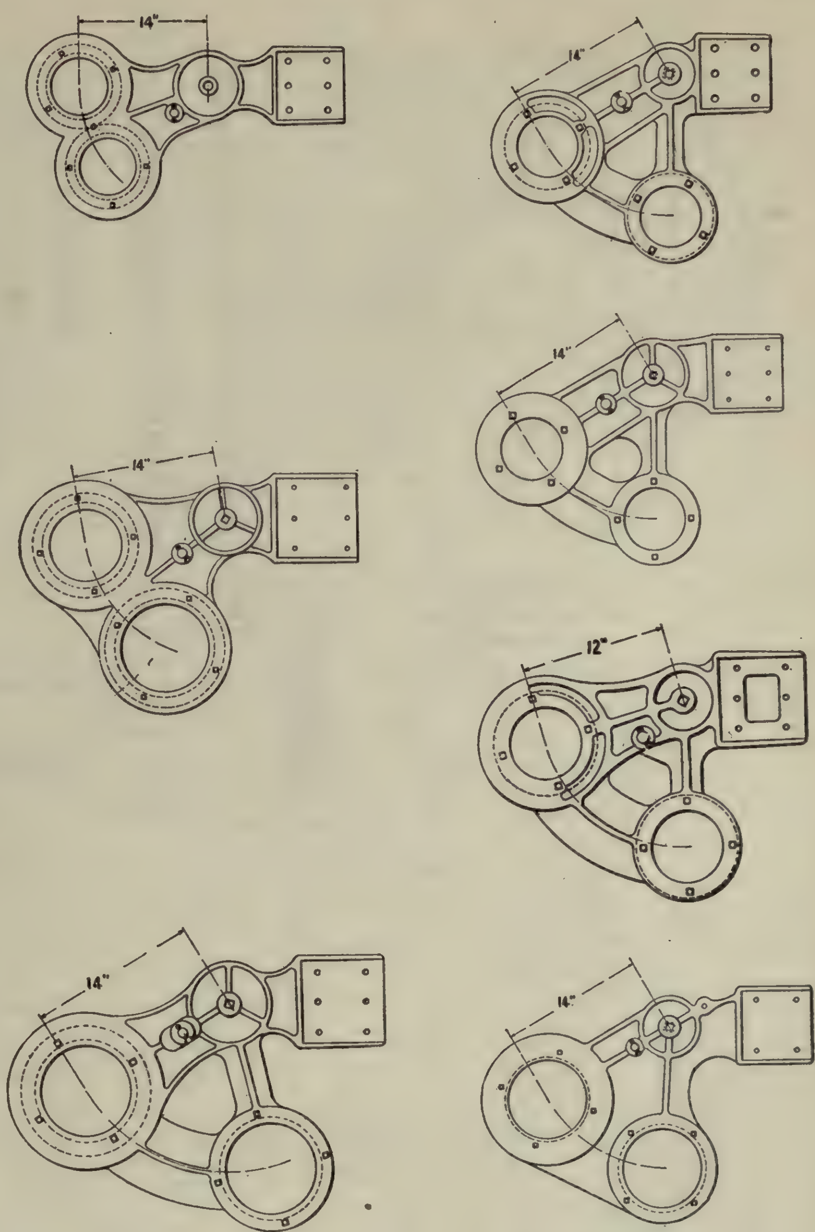


Fig. 3401. Location Plan for Automatic Block Signal in a Cut or on a Fill. Union Pacific.

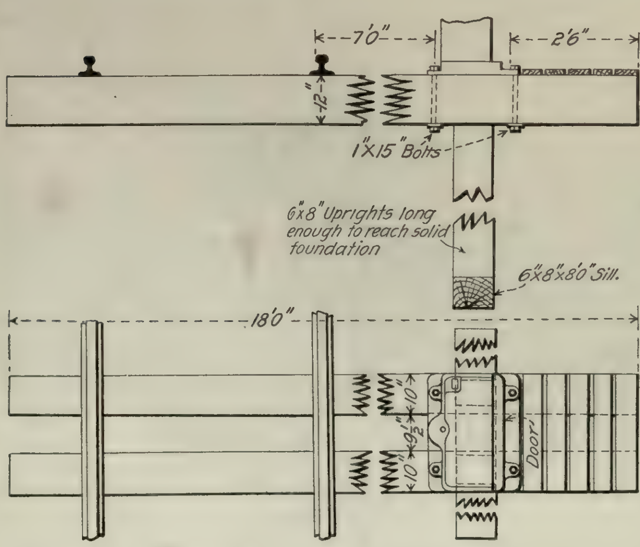
Fig. 3403. 90-Deg. Main Line Semaphore Casting, made to R. S. A. Standard.



Figs. 3404-3408. Types of One-Light Semaphore Castings.



Figs. 3409-3415. Types of Two-Light Semaphore Castings.



Figs. 3416-3417. Timber Foundation for Automatic Block Signals. Southern Pacific-Union Pacific.

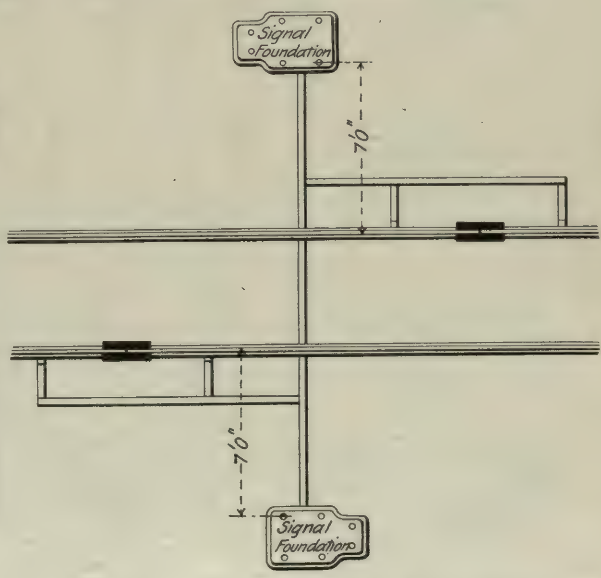
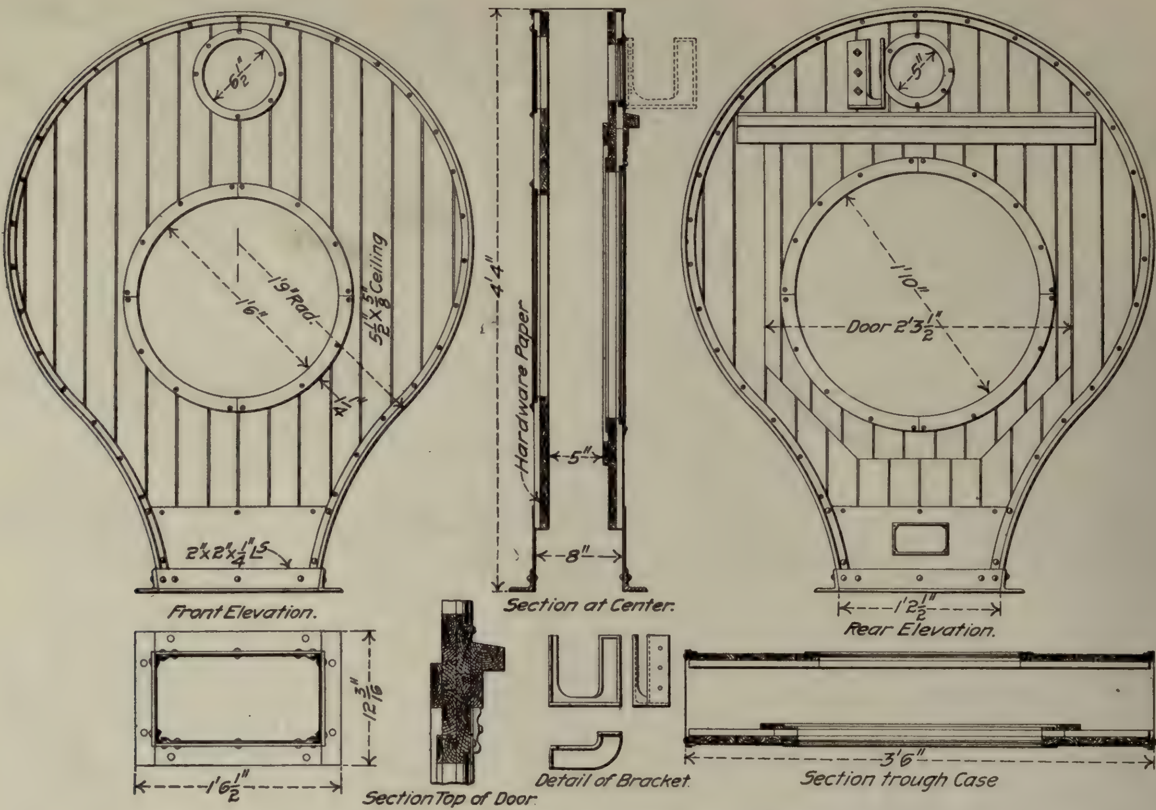
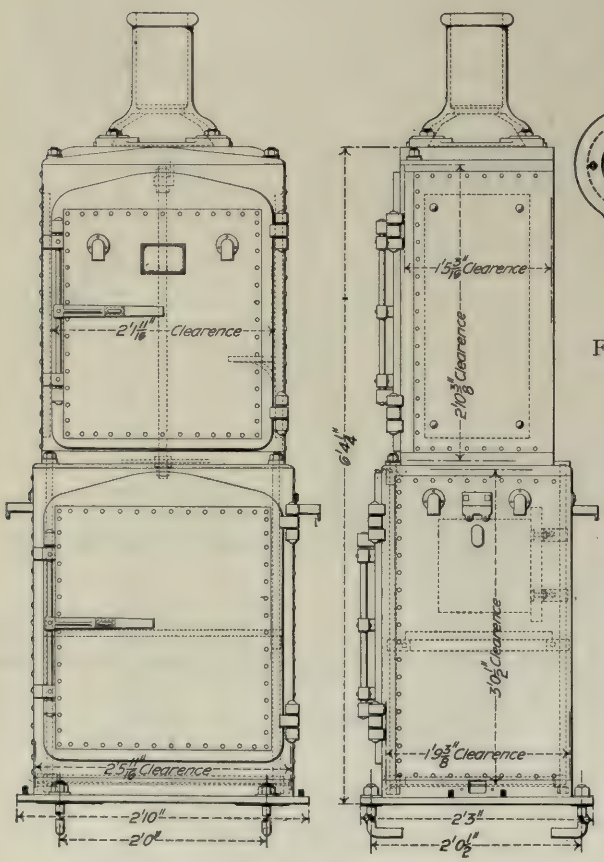


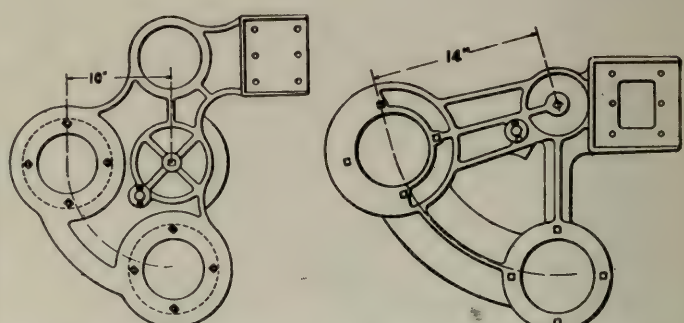
Fig. 3418. Layout for Automatic Block Signals at a Station. Southern Pacific-Union Pacific.



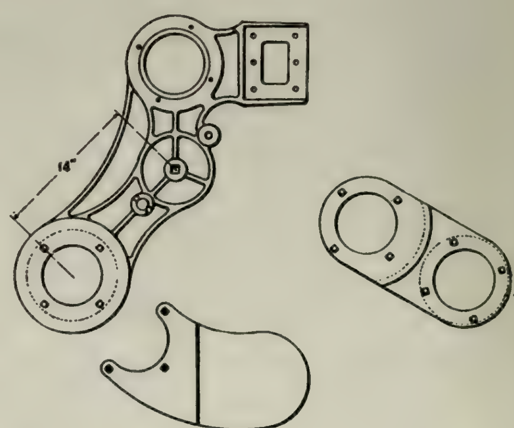
Figs. 3419-3420. Disk Signal Head and Details. Hall Signal Company.



Figs. 3421-3422. Mechanism and Batt ry Case for Electro-Gas or Electric Motor Signal. Hall Signal Company.



Figs. 3423-3424. Types of Two-Light Semaphore Castings.



Figs. 3425-3427. Parts for Converting a Semaphore Casting from One to Two-Light.

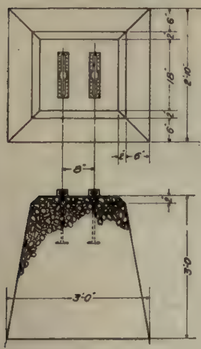


Fig. 3428. Crank Foundation.

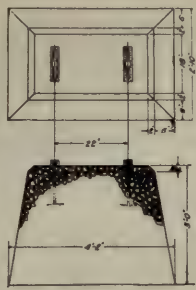


Fig. 3429. Compensator Foundation.

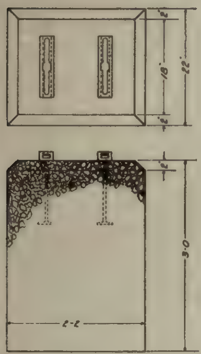


Fig. 3430. Two-Way Wheel Foundation.

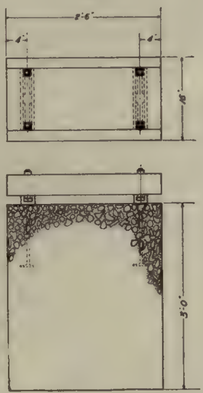


Fig. 3431. Dwarf Signal Foundation.

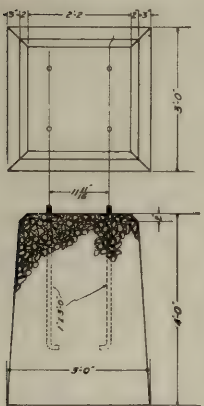


Fig. 3432. Straight Signal Pole Foundation.

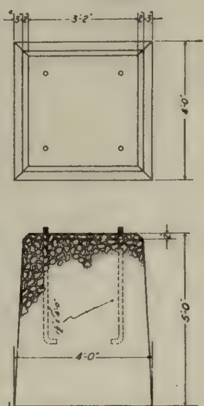


Fig. 3433. Bracket Signal Pole Foundation.

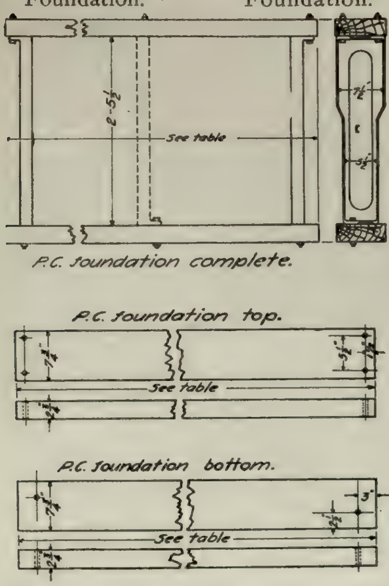


Fig. 3434. Pipe Carrier Foundation.
Figs. 3428-3434. Railway Signal Association Standard Foundations.

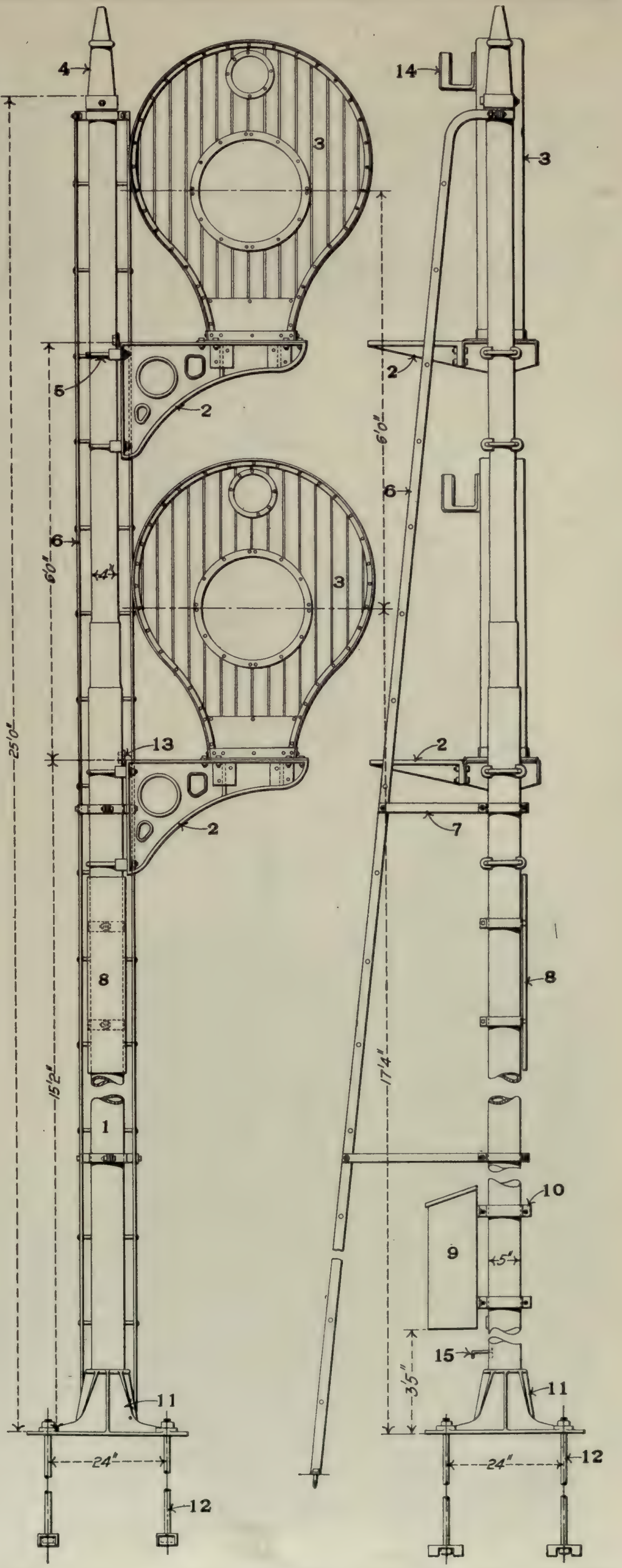


Fig. 3435. Double-Head Disk Signal Mounted on Iron Pipe Post. Hall Signal Company.

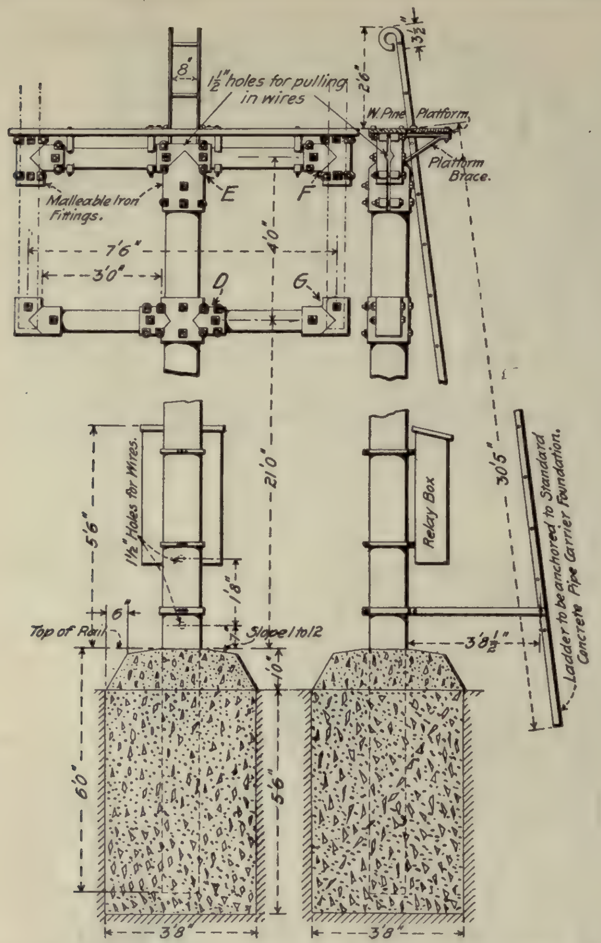
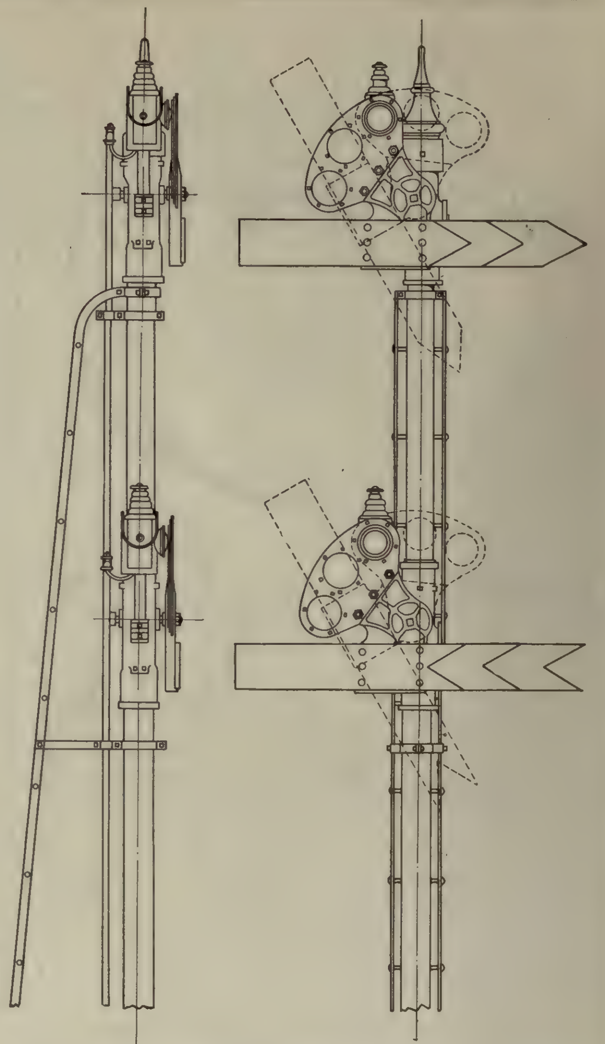


Fig. 3436. Iron Pipe Bracket Post. Philadelphia & Reading.



Figs. 3438-3439. Standard Upper Left Hand Quadrant Semaphore Signal. New York, New Haven & Hartford.

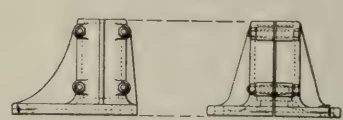
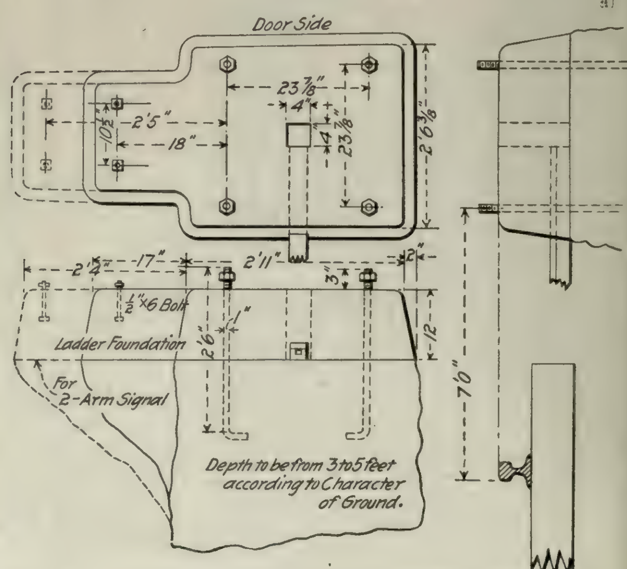
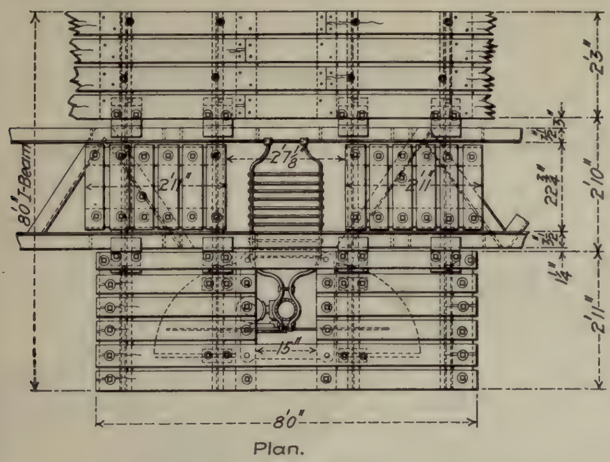


Fig. 3440. Cast Iron Foundation for Iron Pipe Posts.

Fig. 3437. Style B Motor Signal Operated by "Chloride Accumulator" on the Southern Pacific. The Union Switch & Signal Company.



Figs. 3441-3443. Concrete Automatic Signal Foundation. Southern Pacific-Union Pacific.



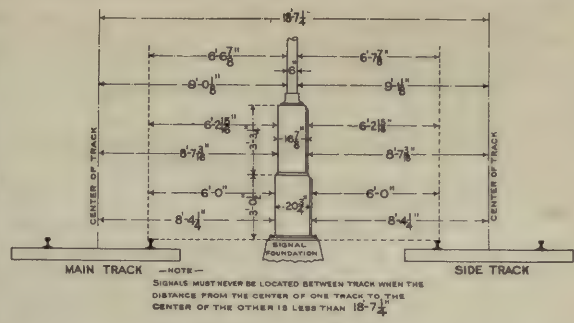
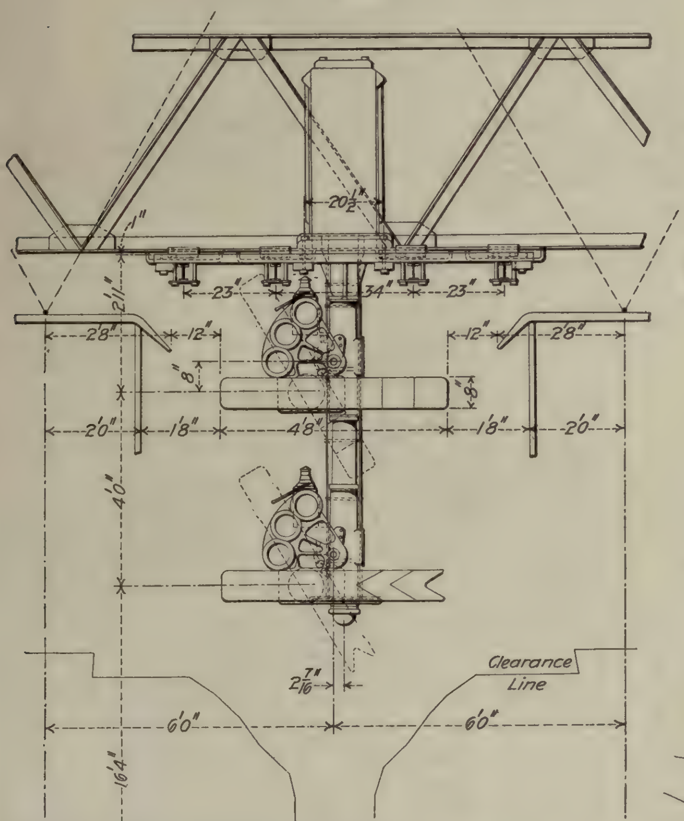
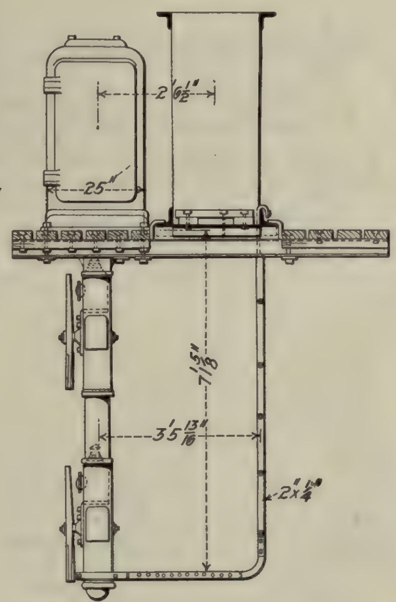
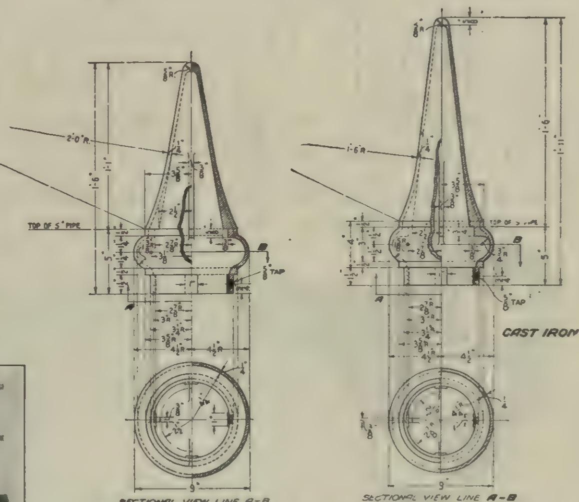


Fig. 3448. Standard Clearance for Signals Located Between Tracks. Sunset Lines.



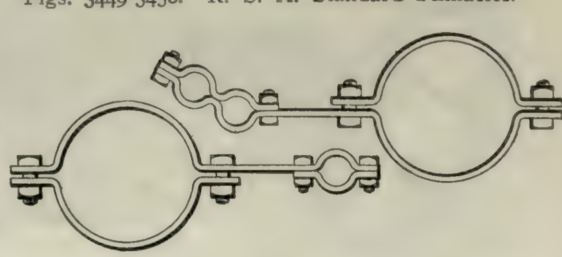


Figs. 3444-3446. Suspended Automatic Block Signal. New York, New Haven & Hartford.



Figs. 3449-3450. R. S. A. Standard Pinnacles.

Fig. 3447. Electro-Pneumatic Interlocking Signals on Bridges. Delaware, Lackawanna & Western.



Figs. 3451-3452. Pipe Guides for Iron Pipe Posts.

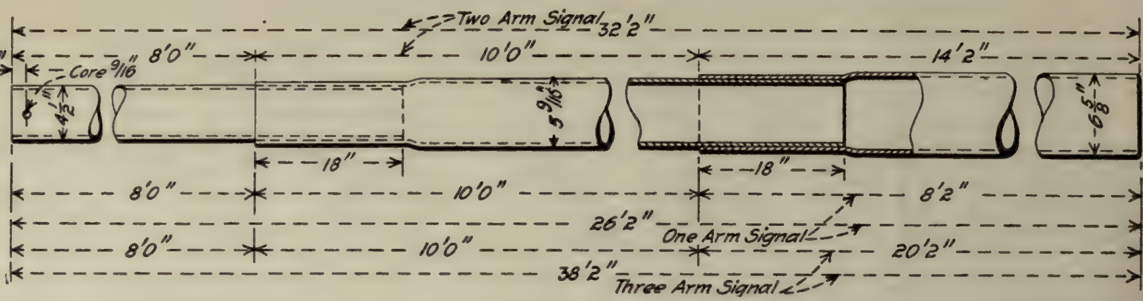
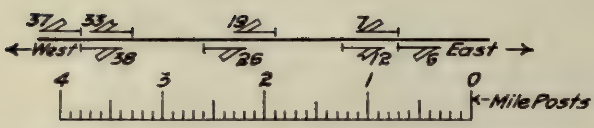
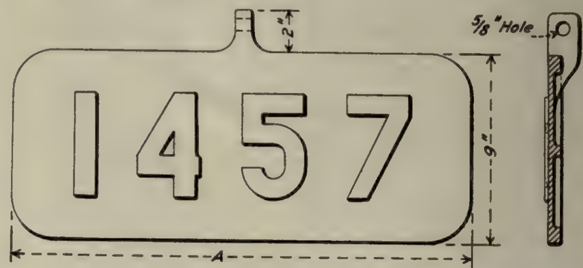


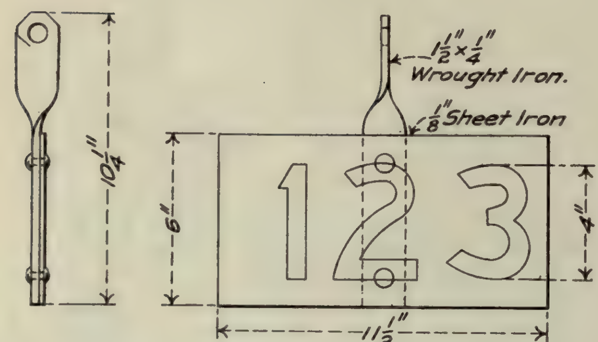
Fig. 3453. Standard Iron Pipe Signal Post. New York Central & Hudson River.



Figs. 3454-3455. Diagram Showing Method of Numbering Automatic Block Signals. Southern Pacific-Union Pacific.



Figs. 3456-3457. Number Plate for Automatic Block Signals. New York Central & Hudson River.



Figs. 3458-3459. Number Plate for Automatic Block Signals. Southern Pacific-Union Pacific.

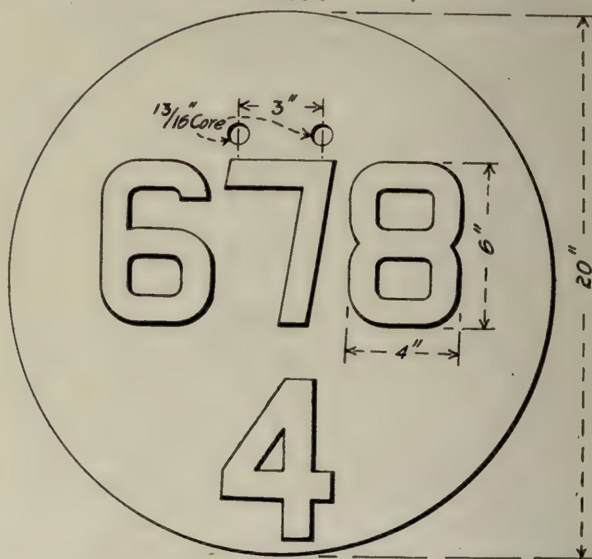
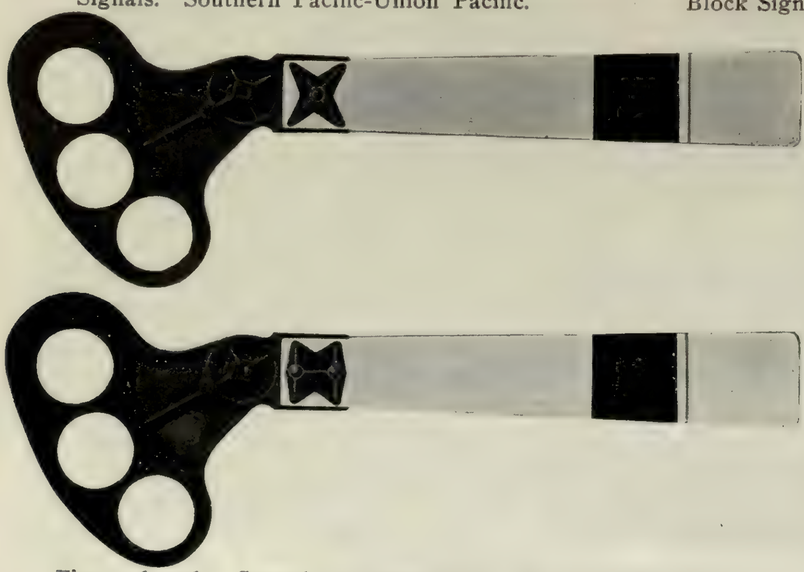
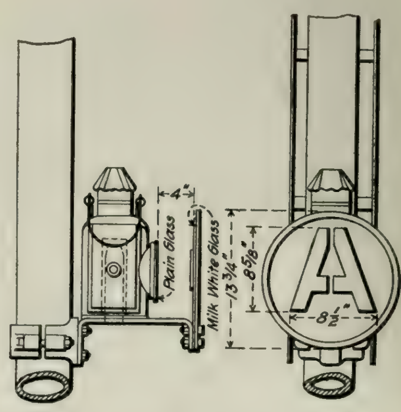


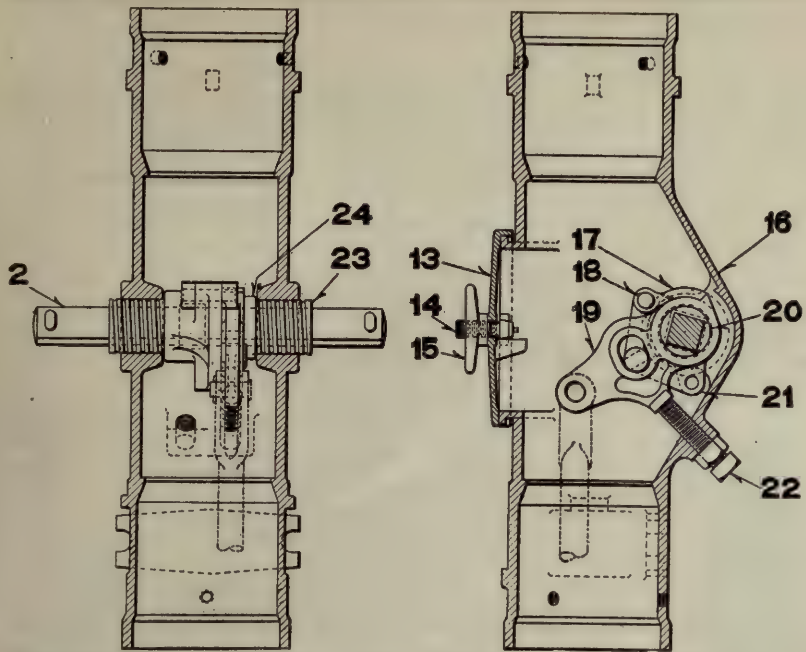
Fig. 3460. Cast Iron Number Plate for Automatic Block Signals. Chicago, Milwaukee & St. Paul.



Figs. 3461-3462. Semaphore Blade Clasps. W. F. Bossert Manufacturing Company.



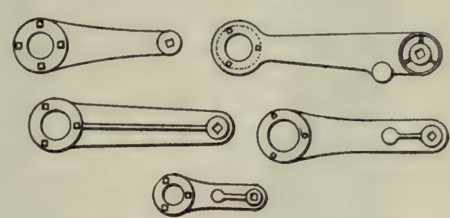
Figs. 3463-3464. Illuminated Automatic Block Signal Marker. Pennsylvania Railroad.



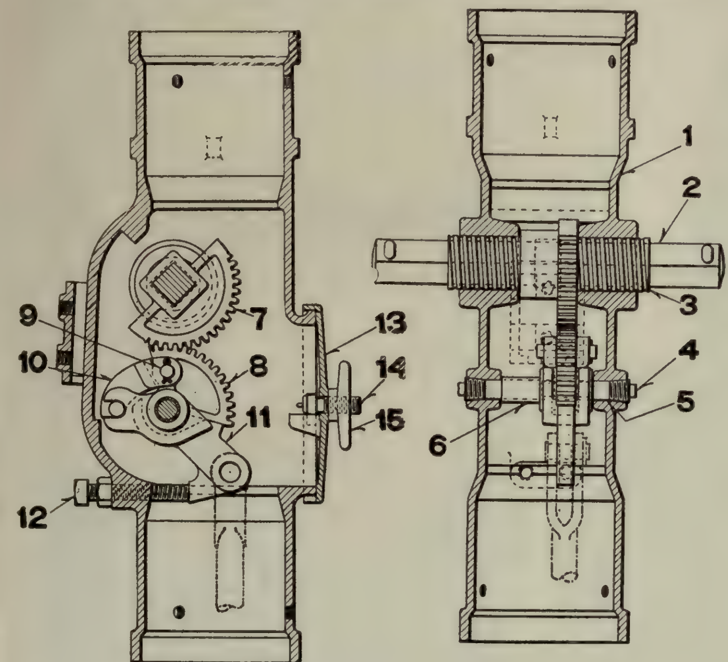
Figs. 3465-3466. Mechanically Locked Semaphore Bearing for 60-Deg. and 75-Deg. Signals. The Union Switch & Signal Company.

Names of Parts Mechanically Locked Semaphore Bearings; Figs. 3465-3468.

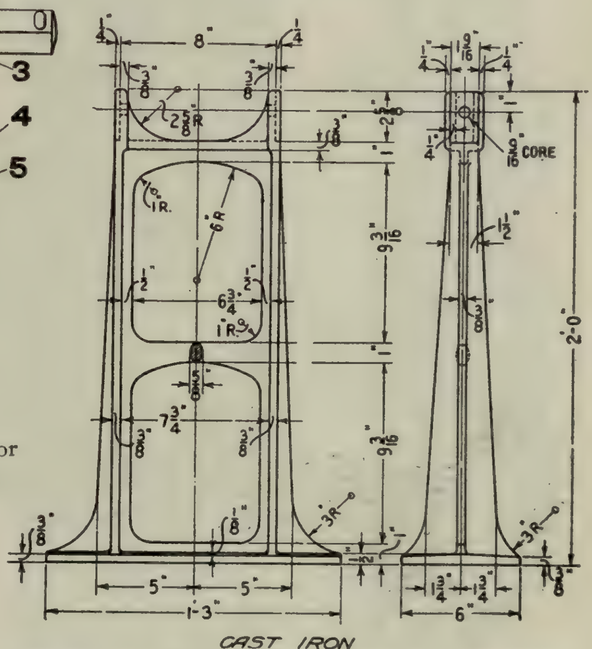
1 *Semaphore Bearing*
2 *Semaphore Shaft*
3 *Journal*
4 *Pipe Plug*
5 *Shaft for Semaphore Crank*
6 *Semaphore Crank Shaft Separator*
7 *Segment*
8 *Segment*
9 *Pin and Cotters*
10 *Pawl*
11 *Semaphore Crank*
12 *Adjusting Bolt*
13 *Hand-hole Plate*
14 *Hand-hole Plate Clamp*
15 *Handle*
16 *Semaphore Bearing*
17 *Pawl*
18 *Pin*
19 *Female Half of Semaphore Crank*
20 *Bushing*
21 *Male Half of Semaphore Crank*
22 *Adjusting Bolt*
23 *Journal*
24 *Semaphore Shaft Separator*



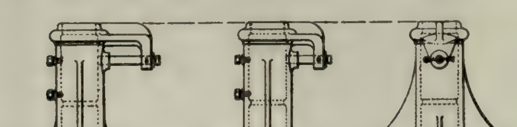
Figs. 3472-3476. Types of Back Spectacles.



Figs. 3467-3468. Mechanically Locked Semaphore Bearing for 90-Deg. Signals. The Union Switch & Signal Company.



Figs. 3477-3478. Cast Iron Ladder Foundation. Railway Signal Association Standard.



Figs. 3469-3471. Cast Iron Signal Foundations and Balance Lever Stands Combined.

Figs. 3465-3466 show a mechanically locked semaphore bearing made by the Union Switch & Signal Co. The object of this device is to prevent a signal from being cleared by any other means than the up and down rod. Figs. 3467-3468 are used for 90° signals. The up and down rod is attached to one end of semaphore crank 11, which has a jaw at its other end. In this jaw rests a lug, at the end of pawl 10. 10 is pinned to segment 8, which rests against a lug on 11. 8 engages with 7 to clear the signal when the rod is raised. If any attempt is made to clear the signal by moving the semaphore casting the lug at the end of 10 will slip out of the jaw and 10 will engage the projection of the bearing casting, thereby preventing movement of the semaphore casting.

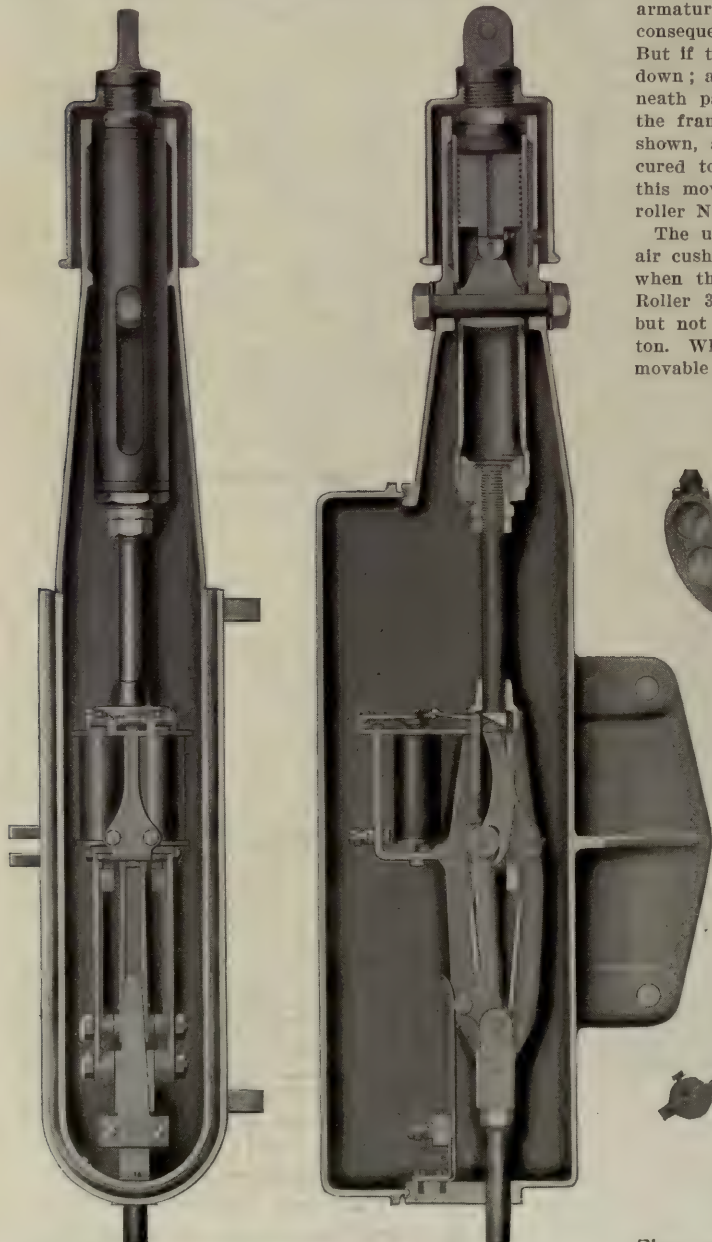
Figs. 3465-3466 are used for 60° and 75° signals. The up and down rod is attached to crank 19, which turns loosely on the semaphore shaft. Casting 21 is rigidly attached to the shaft. It carries a lug which projects through the opening in 19. Pawl 17 is pinned to 21 and rests normally in a depression of the circumference of 19. Any attempt to clear the signal from the semaphore casting will cause 17 to slide out of its seat and engage in the notch of the casting 16, thereby preventing movement of the semaphore casting.

ELECTRO-MECHANICAL SLOTS

The electro-mechanical slot, when separate from the signal operating mechanism, is placed in the line of connection to mechanically operated signals in order to insure that a signal will indicate stop even though the lever to which it is connected may not have been restored to the normal position after the passage of a train. It is particularly valuable at the entrance to the first block in a series of controlled manual blocks insuring the restoration of the initial signal to the stop position and its lever to normal after the passage of a train, thus preventing other trains following on the same clear indication.

UNION ELECTRO-MECHANICAL SLOT.

The electro-mechanical slot made by the Union Switch & Signal Co. is shown in Figs. 3479-3485. As will be seen from Figs. 3481-3482 the up and down rod, which is moved upward to clear the signal, is carried through an iron box, fixed to the

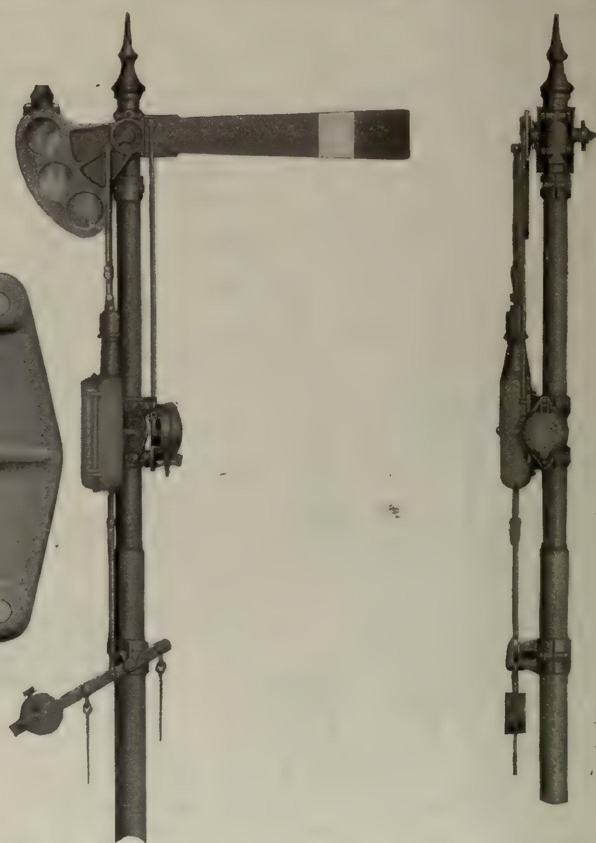


Figs. 3479-3480. Electro-Mechanical Slot. The Union Switch & Signal Company.

signal post between the signal arm and the balance lever. Referring now to Figs. 3483-3485, the frame K and the parts attached to it move up and down with the rod. The electromagnet M, when energized, keeps rods U and E rigidly connected and the signalman has full control of the signal. When the magnet is de-energized the lifting of the rod U does not lift E, and consequently has no effect on the signal arm. Rod U is connected at its lower end to the balance lever and to frame K at J. Frame K supports the magnet, the guide K', spring L and bolts J and H. The lever G is pivoted so as to move radially on H. Spring T is fixed to the bottom of the case and presses against roller I, in lever G, normally holding the latter in position shown. Roller N, in lever G, rests under pawl F, which is pivoted in rod E at X.

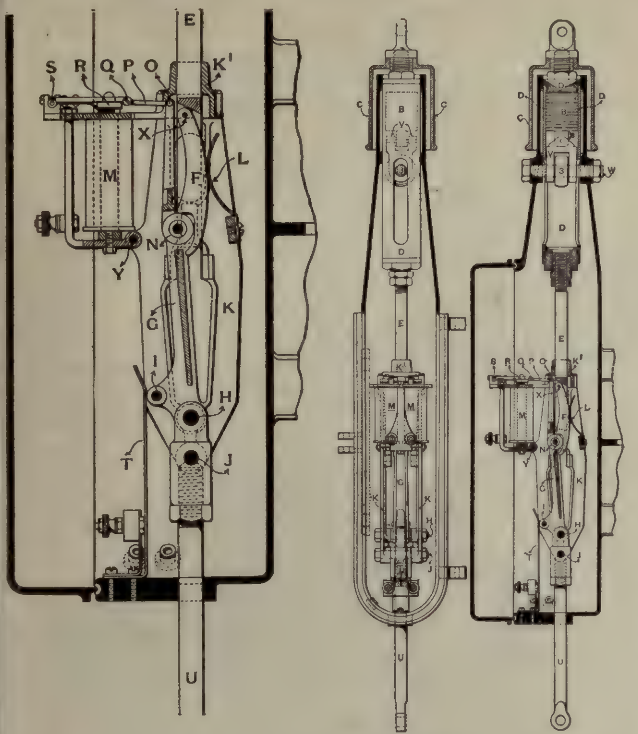
The centers H, N and X, are normally (when signal operating lever is normal) out of line. Any upward pressure applied at H consequently tends to move lever G, to the left on H, as a pivot. This causes roller N to move from beneath the pawl F, which is not movable to the left, as a result of the resistance offered by the weight of the semaphore casting pressing downward at X upon pawl F. When magnet M is energized this movement sidewise of G is resisted at O, its upper extremity, as the link P pivoted thereto is held down by the armature R. Pivots S, Q and O are normally out of line, so that when M is de-energized any attempt to move G to the left causes armature R to move upward, the pivot S being fixed, and consequently permits the roller N to move from under pawl F. But if the magnet M is energized its power is ample to hold R down; and thus to prevent the movement of roller N from beneath pawl F. Consequently any upward pressure on U lifts the frame K bodily with all members of the slot engaged as shown, and the signal is thereby cleared. Spring T, being secured to the case ceases to press against lever I the instant this movement begins, and hence its normal tendency to force roller N under pawl F is not present when the signal is clear.

The upper part of the slot is so designed as to provide an air cushion for relieving the shock that would otherwise result when the signal returned automatically to the stop position. Roller 3 is a guide, traveling on the inside of the cylinder, but not at any time touching the surface covered by the piston. When a signal has been put in the clear position, all the movable parts, K, M, F, etc., are in the upper part of the



Figs. 3481-3482. Electro-Mechanical Slot and Rotary Circuit Controller Applied to a Pipe Post Signal, Wire Connected.

case, and E, D, B, C, etc., are at the upper extremity of their stroke. Point I is free from spring T. Then, when a train passes and, by shunting the track circuit, de-energizes M, the armature R is released and the weight of the semaphore casting, acting through the several members described, forces the roller N from under F. The rod E, with its attachments B, C, D, then drops by gravity, restoring the signal to the stop position. If now the signalman pulls the rod U down again and attempts to clear the signal a second time (before M has



Figs. 3483-3485. Electro-Mechanical Slot. The Union Switch & Signal Company.

Names of Parts, Electro-Mechanical Slot; Figs. 3483-3485.

B	*Buffer Piston*	N	*Roller*
C	*Buffer Shield*	O	*Pivot Bolt*
D	*Buffer Cylinder*	P	*Link*
E	*Connecting Rod*	Q	*Pivot Screw*
F	*Pawl*	R	*Armature*
G	*Swinging Lever*	S	*Pivot Screw*
H	*Bolt*	T	*Spring*
I	*Bolt*	U	*Up and Down Rod*
J	*Bolt*	V	*Jaw*
K	*Slide Plate Frame*	W	*Bolt*
K¹	*Guide*	X	*Pivot Bolt*
L	*Spring*	Y	*Bolt*
M	*Magnet*		

been re-energized) he can push up U, J, N, M, etc., but this movement will have no effect on F and E, and the signal will remain in the stop position. When the train goes out of the block section, M is energized and the signalman's control over E, and the signal is restored.

HALL ELECTRO-MECHANICAL SLOT.

The Hall Signal Company's electro-mechanical slot for semaphore signals, shown in Figs. 3486-3487, is designed to be mounted near the base of the signal post, where it will be easily accessible. All movable parts can be plainly seen and easily inspected or removed without dismembering the entire mechanism. The case is roomy but not over large, and the magnet is fixed. The details and construction are shown in Figs. 3486-3487. In Fig. 3486 A represents the cast iron case; B is the lower operating rod, and C the upper operating rod, carrying the dashpot Q, attached in the usual way. D is a powerful iron-clad magnet mounted on a stand which is rigidly fastened to the case; E is the armature secured loosely to the lever F by the threaded pin G. G is slightly smaller than the hole in F, through which it passes, and has a semispherical head, after the manner of a ball and socket joint. This is to allow E to make good contact with D, despite any small lack of adjustment in F. Lever F is pivoted at O. H is a phosphor bronze spring used to restore lever F to its normal

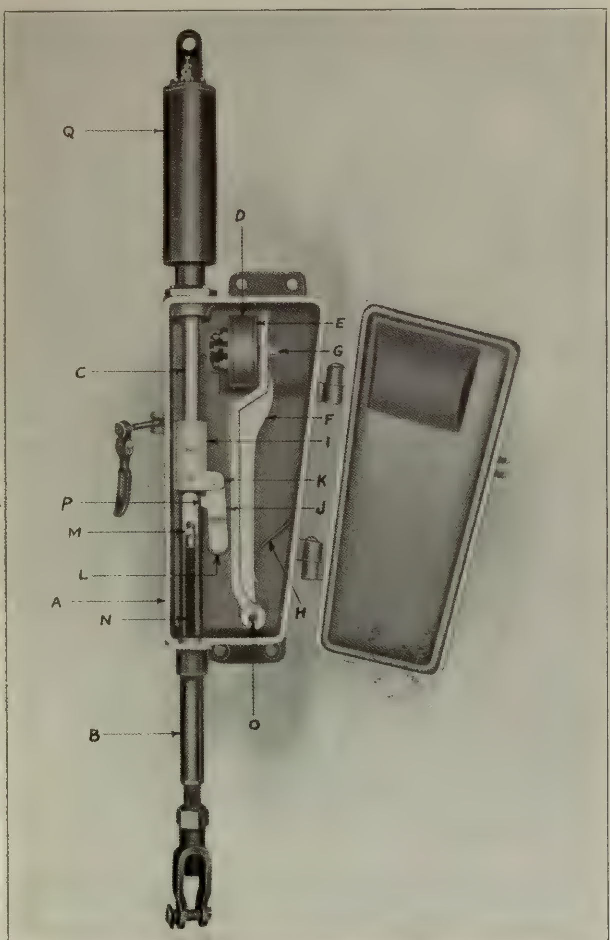


Fig. 3486. Single Electro-Mechanical Slot. Hall Signal Company.

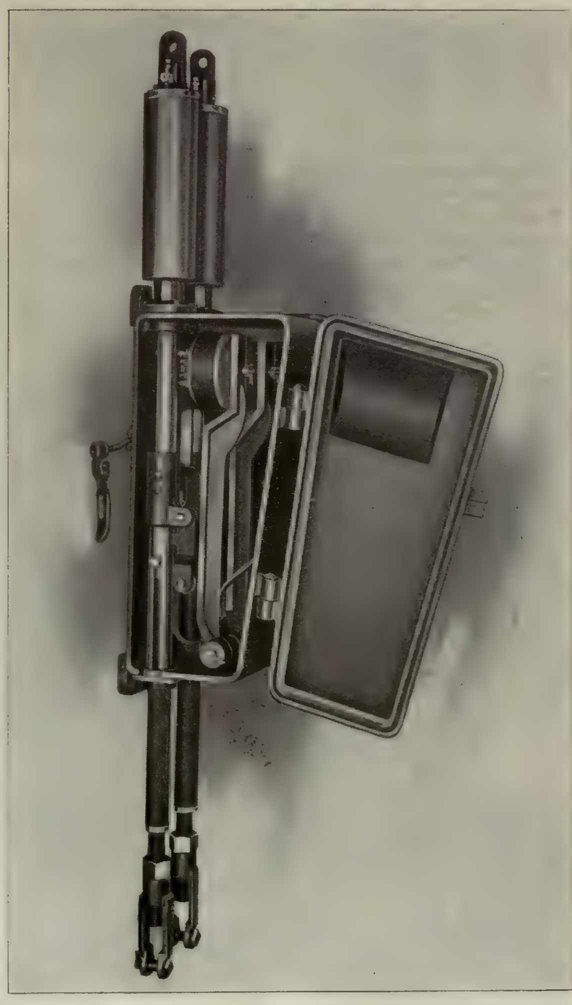


Fig. 3487. Double Electro-Mechanical Slot. Hall Signal Company.

position, but exerts no appreciable pressure otherwise. I is a cast-iron sleeve riveted to the lower rod B, and carries the latch J, pivoted to the lug K, which is part of the sleeve I; J carries a roller L, to reduce friction when traveling against lever F. The lower end of C extends within B, and carries a pin M, working in slot N, cut in B. This is to allow the signal to be pulled to the stop position, as M projects beyond the edge of B, on both sides. Both rods are notched at P, to allow the projection of latch J to engage with upper rod C. When the magnet D is energized the signal can be cleared. The magnet holds F against latch J by pressing against roller L, and then if B is raised C must also go up, for latch J will engage with lower end of C. If, while the signal is in the clear position, magnet D becomes de-energized the weight of the semaphore casting acting against lever F, through C and latch J, will force F away from D; and J, in tripping, will allow C to pass by, and the signal will assume the stop position. When F is forced away from D it compresses spring H, which remains compressed until B has been restored to its normal position, allowing J again to enter the notch P; when this occurs H restores F to contact with D. If it is attempted to

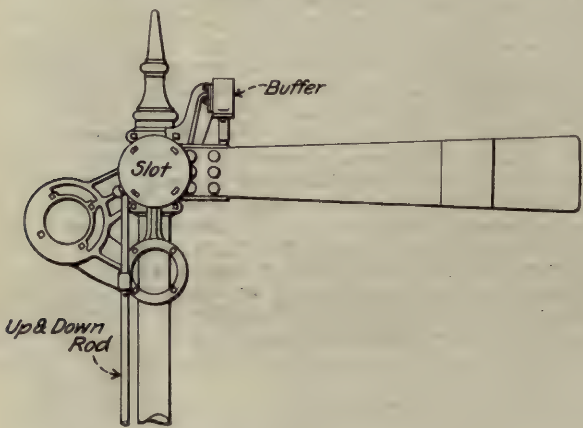


Fig. 3488. Application of Electro-Mechanical Spindle Slot. General Railway Signal Company.

clear the signal when D is de-energized, F will be forced back in the same manner as above described.

The double slot, shown in Fig. 3487, is used where two arms of a signal are slotted, and is much more compact and convenient than two single slots. This slot consists essentially of the mechanism of two single slots mounted side by side in one case, and it operates exactly as above described.

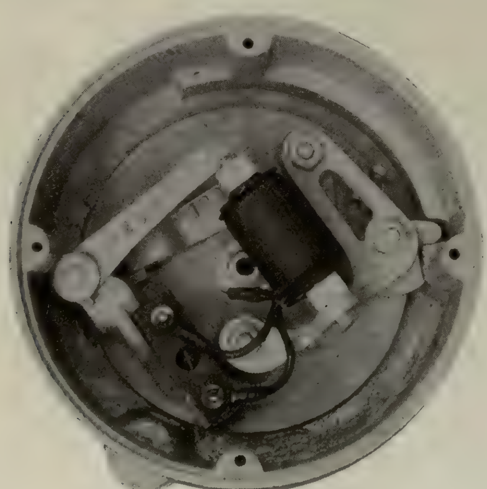


Fig. 3491. Electro-Mechanical Spindle Slot Energized and Signal Clear.

G. R. S. SPINDLE SLOT.

The spindle slot made by the General Railway Signal Company is designed to be placed on the spindle of a signal as shown in Figs. 3488-3492. It consists of a circular iron case provided with a lug, Figs. 3490-3492, to which the up and down rod is attached. This case turns loosely on the spindle. Inside is a circular disk provided with a square hole Figs. 3490-3492, in the center for attaching to the spindle. On the disk is mounted the mechanism. This consists of a frame supporting the magnets and a dog in the form of the segment of a circle and a projection. The projection rests normally in a notch in the

Fig. 3489. Semaphore Shaft Used with Electro-Mechanical Spindle Slot.

circumference of the case, Figs. 3490-3492. In the upper part of the frame is pivoted a lever, whose arms are at right angles The short arm rests normally against the upper face of the

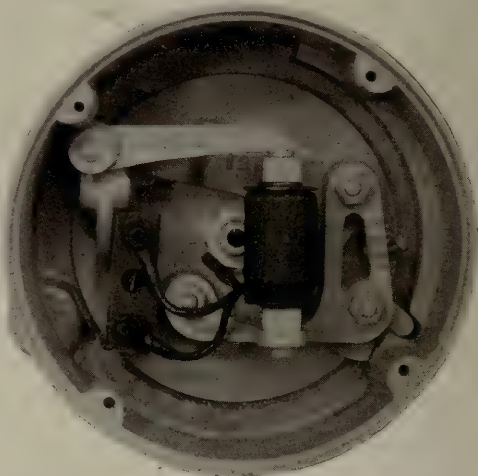


Fig. 3490. Normal Condition of Electro-Mechanical Spindle Slot. General Railway Signal Company.

dog. The long arm carries a roller working in a jaw keyed to the pin which carries the armature arm. This pin is supported by a projection on the disk. When the magnet is energized the armature acting through its arm and the jaw and lever holds the dog in the notch, and the signal can be cleared.

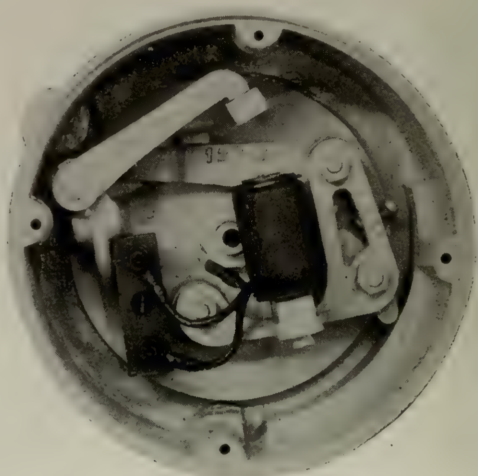


Fig. 3492. Electro-Mechanical Spindle Slot Disengaged. Signal About to Assume the Stop Position.

Fig. 3491. When the magnet is de-energized the counterweight of the signal forces the dog out of the notch and trips the armature, as shown in Fig. 3492. All shock is absorbed by a dash pot mounted on a bracket above the arm casting so arranged that the casting will strike against the piston rod, as shown in Fig. 3488.

SWITCH MACHINES AND SWITCH STANDS

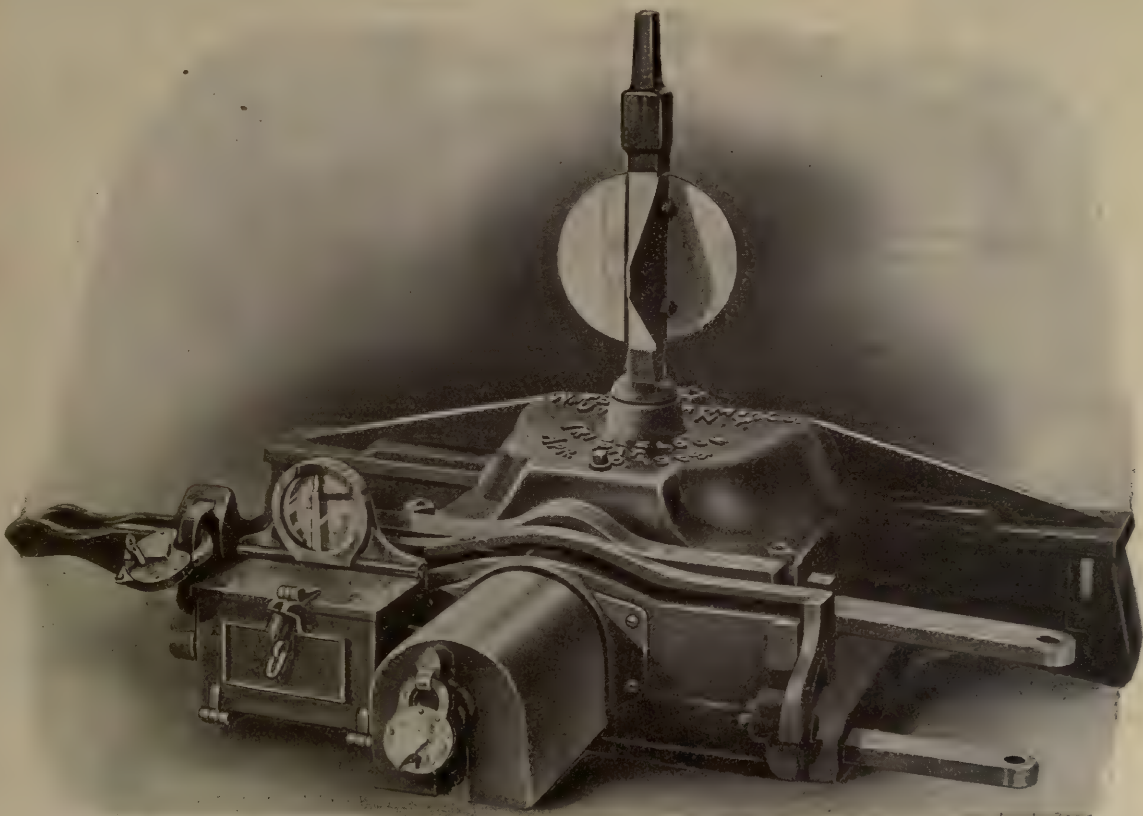


Fig. 3493. Triplelock Switch Machine. W. F. Bossert Manufacturing Company.

TRIPLELOCK SWITCH MACHINE.

The W. F. Bossert Mfg. Co. manufactures a switch machine arranged to interlock a signal. It has an operating lever parallel to the track which unlocks the point, throws the switch cleared until the switch lever has been returned to its normal position and switch points locked. The machine will not operate unless the movement of the switch points corresponds with the movement of the operating lever.

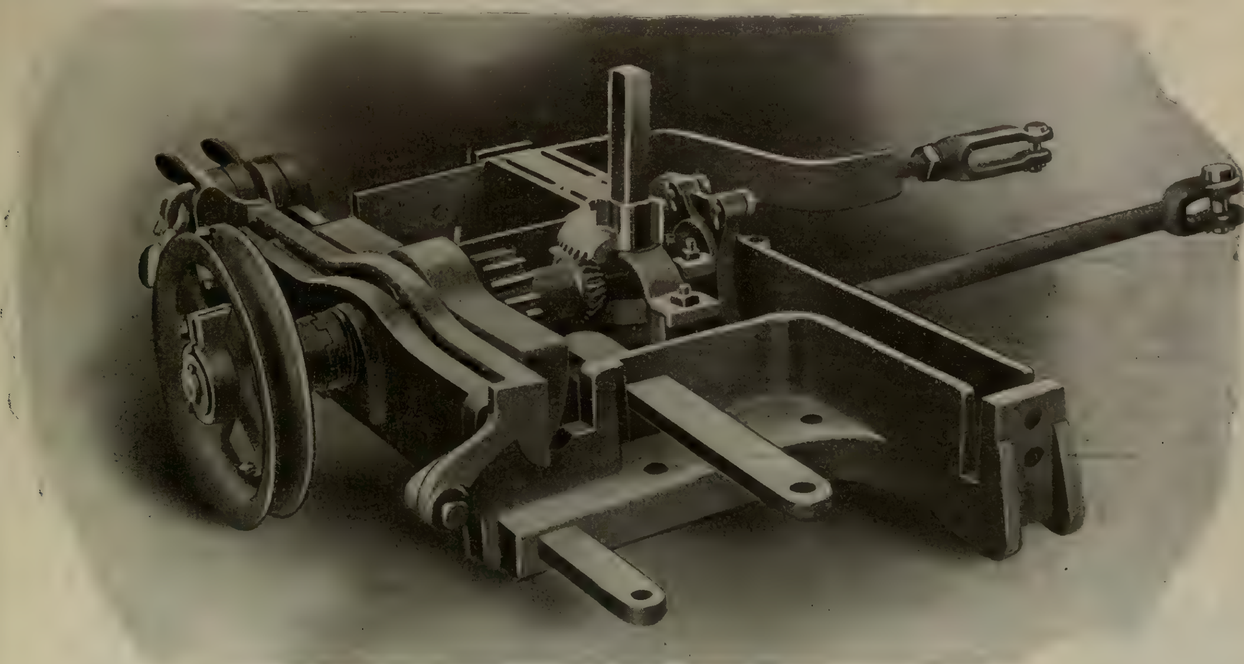


Fig. 3494. Triplelock Switch Machine Open, Showing Wheel and Derail Movement of Lock.

and re-locks the points in both positions with the facing-point lock.

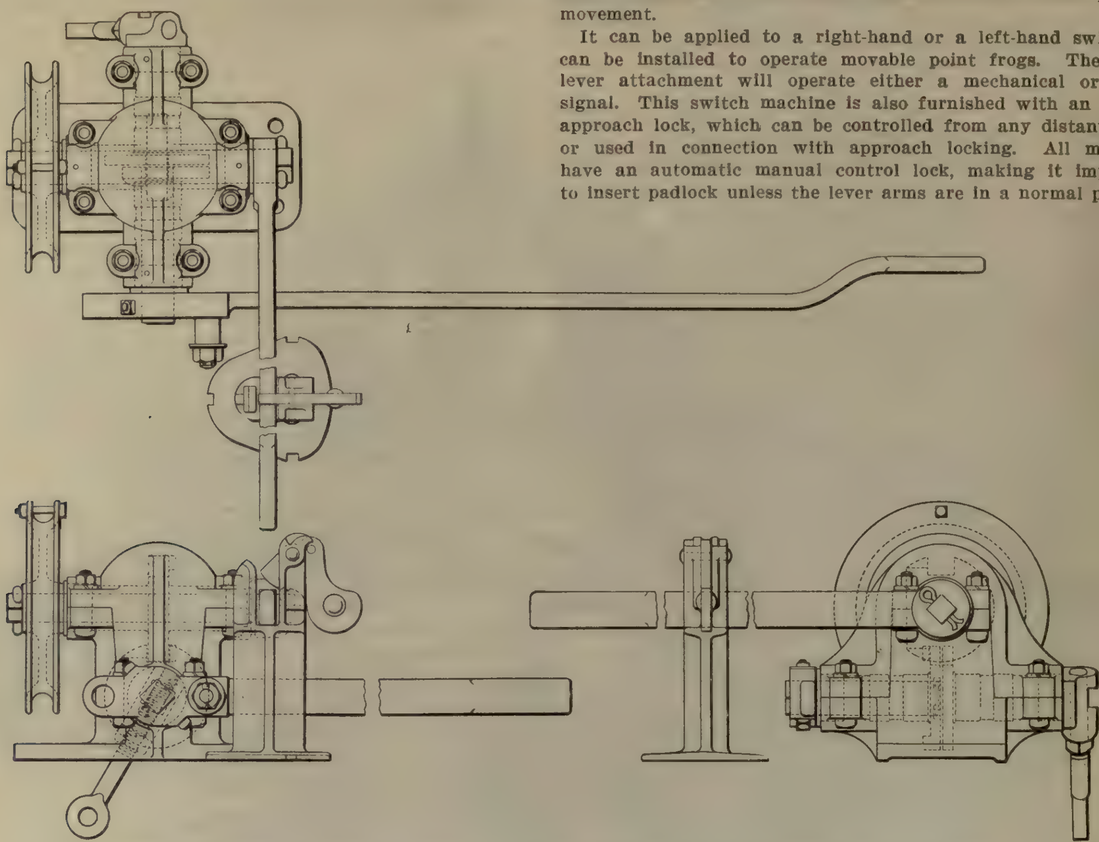
The lever lock between the switch and the signal lever is so arranged that the signal lever must be in the full lock position before the switch lever can be moved, and after the switch lever movement has been started the signal lever cannot again be

A dust and waterproof circuit controller, attached to the signal lever, takes the place of a switch controller operated by the movement of the switch points.

The switch points and the derail are thrown at the same time, both being operated direct from the operating lever and independent of each other outside of the switch stand. The

derail connection in the switch stand has seven inches positive movement.

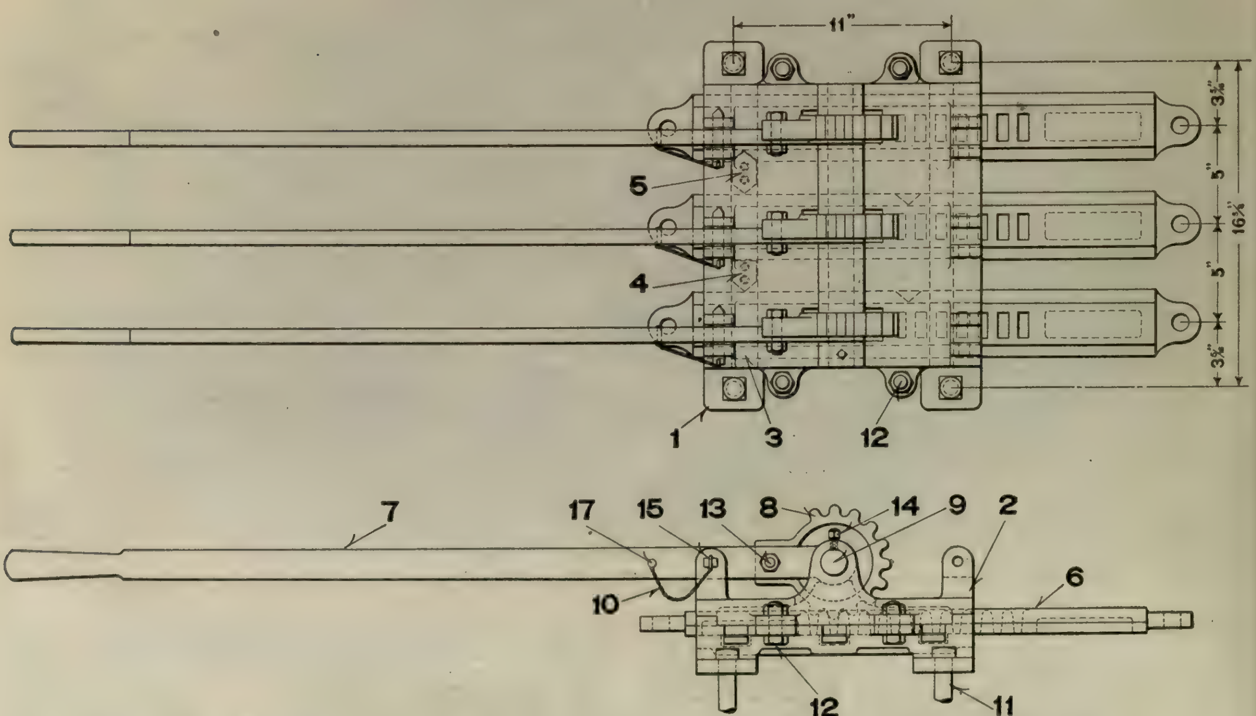
It can be applied to a right-hand or a left-hand switch, or can be installed to operate movable point frogs. The signal lever attachment will operate either a mechanical or power signal. This switch machine is also furnished with an electric approach lock, which can be controlled from any distant point, or used in connection with approach locking. All machines have an automatic manual control lock, making it impossible to insert padlock unless the lever arms are in a normal position.



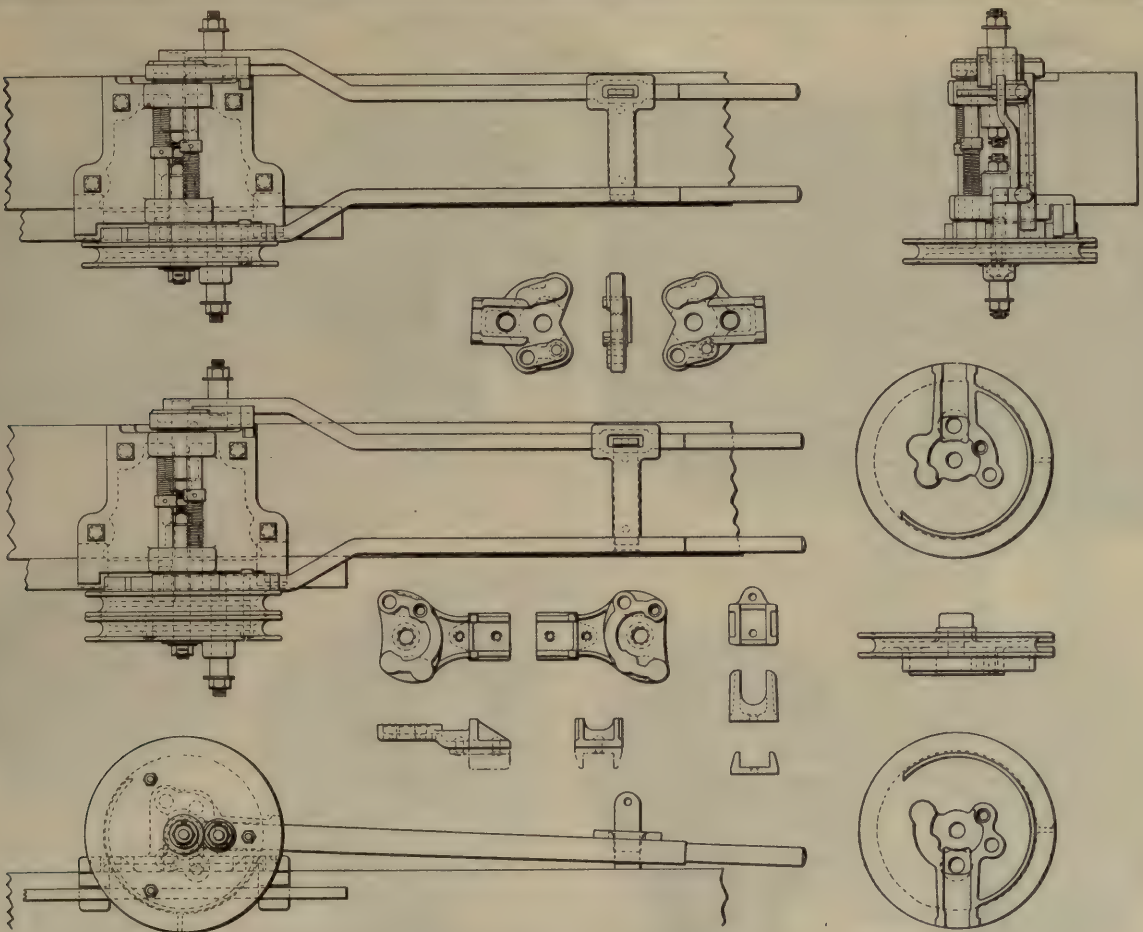
Figs. 3495-3497. Double Ground Lever Interlocking Stand, with Disk Locking. The Union Switch & Signal Company.

Names of Parts, Triple Ground Lever Interlocking Stand; Figs. 3498-3499.

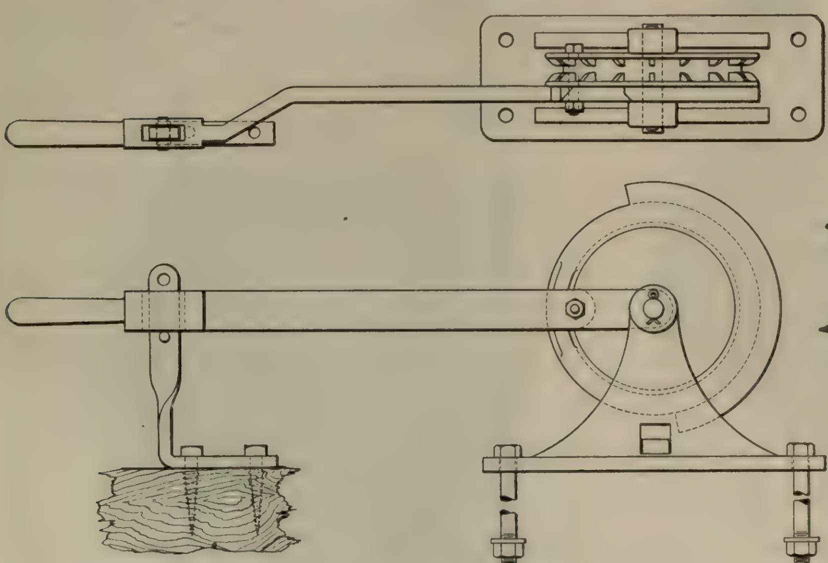
1	*Base*	5	*Dog*	9	*Shaft*	13	*Bolt*
2	*Cap*	6	*Rack*	10	*Chain*	14	*Set Screw*
3	*Dog*	7	*Lever*	11	*Bolt*	15	*Locking Pin*
4	*Dog*	8	*Pinion*	12	*Bolt*	17	*Rivet*



Figs. 3498-3499. Triple Ground Lever Interlocking Stand. The Union Switch & Signal Company.



Figs. 3500-3508. Double Ground Lever Interlocking Stand. The Union Switch & Signal Company.



Figs. 3509-3510. Rim Lock Ground Lever Interlocking Stand. The Union Switch & Signal Company.

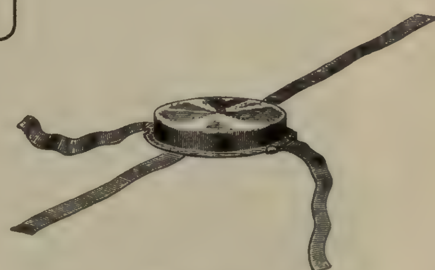


Fig. 3511. Torpedo.

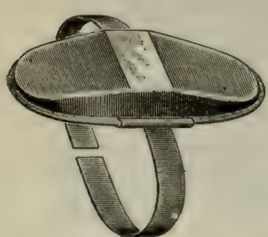
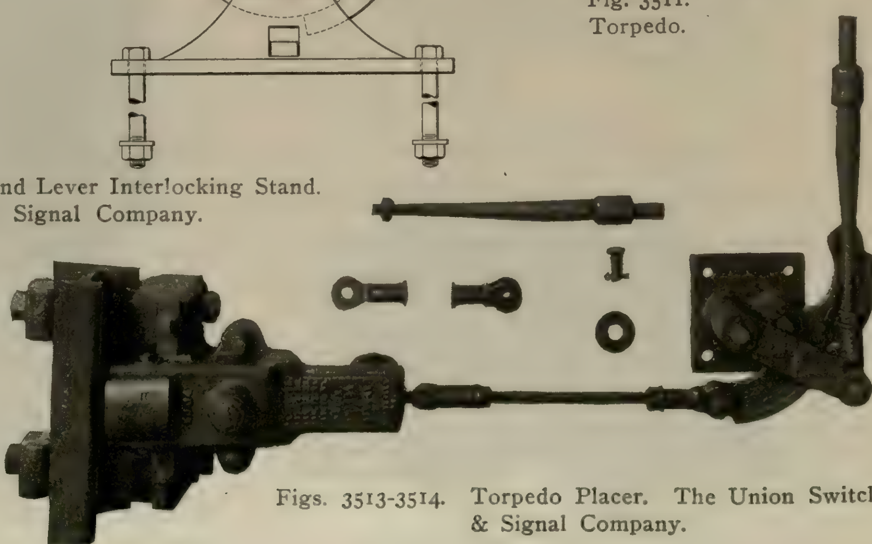


Fig. 3512. Torpedo.



Figs. 3513-3514. Torpedo Placer. The Union Switch & Signal Company.

TESTING INSTRUMENTS

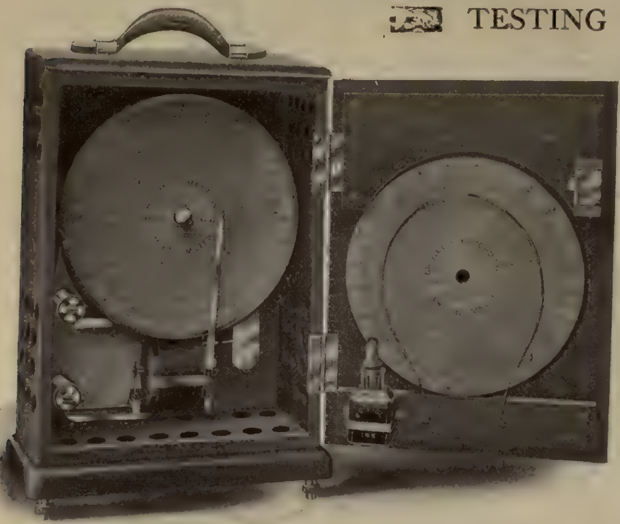


Fig. 3515. Portable Recording Ammeter.

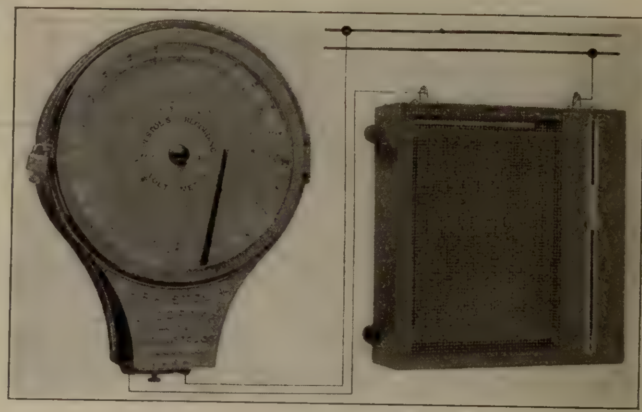


Fig. 3516. Recording Voltmeter and Resistance Box Showing Connections.

Fig. 3517. Recording Voltmeter, Front View.

Fig. 3518. Recording Voltmeter, Rear View,

Fig. 3519. Recording Pressure Gage, Rear View, Cover Removed.

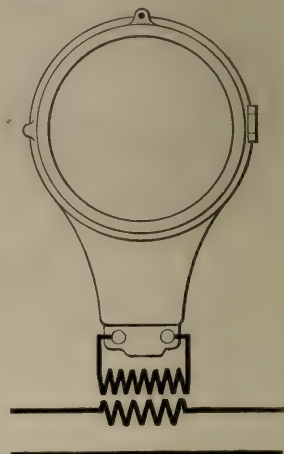


Fig. 3520. Circuit Diagram Recording Ammeter with Current Transformer for Alternating Current.

Figs. 3515-3520. Recording Instruments. Bristol Company.

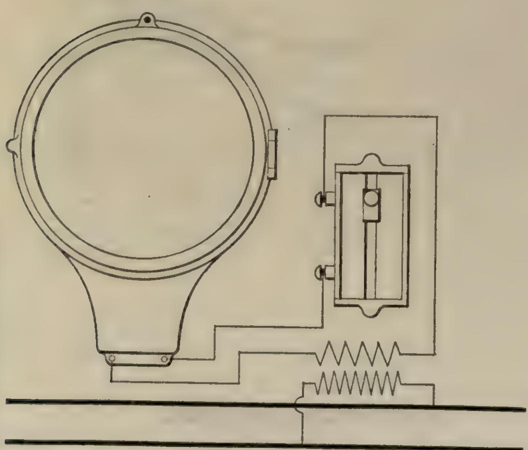


Fig. 3521. Circuit Diagram Recording Voltmeter with Potential Transformer for Alternating Current.

Fig. 3522. Recording Pressure Gage in Case. Bristol Company.

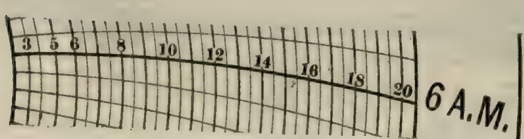


Fig. 3523. Section of Recording Ammeter Chart.

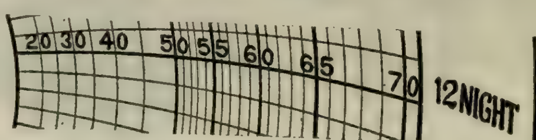


Fig. 3524. Section of Recording Voltmeter Chart.

Fig. 3525. Switchboard Ammeter.

Fig. 3526. Switchboard Voltmeter.

Fig. 3527. Edgewise Switchboard Voltmeter.

Figs. 3525-3527. Electrical Measuring Instruments. Weston Electrical Instrument Company.

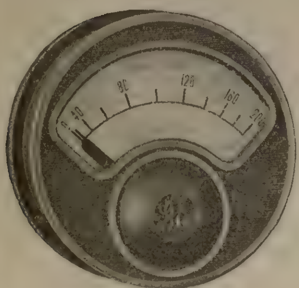


Fig. 3528. Switchboard Instrument. Ammeter or Voltmeter. General Electric Company.

Fig. 3529. Synchronism Indicator. General Electric Company.

Fig. 3530. Portable Direct Current Voltmeter.

Fig. 3531. Portable Alternating Current Voltmeter.

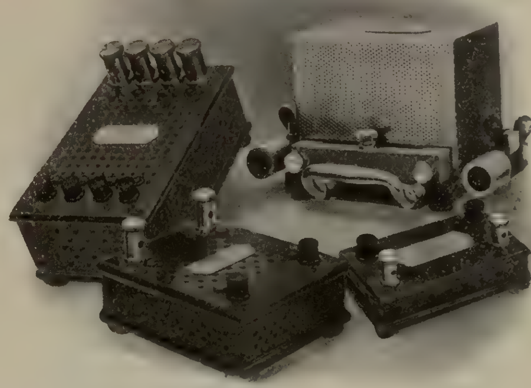


Fig. 3532. Portable Alloy Shunts.

Fig. 3533. Portable Direct Current Volt-Ammeter.

Fig. 3534. Portable Milli-Ammeter.

Figs. 3530-3534. Electrical Measuring Instruments. Weston Electrical Instrument Company.

GENERAL ELECTRIC DIRECT CURRENT INSTRUMENTS.

For general testing on direct current, an instrument of the permanent-magnet D'Arsonval type is to be preferred. These instruments show polarity, and have very low internal losses, as the permanent magnet furnishes a good part of the energy necessary to operate the instrument. The moving elements of this type of instrument are very light and the indications quite "dead beat" or well damped. The damping feature is obtained by the Foucault currents generated in the aluminum frame on which the wire for the moving coil is mounted. This frame moves across the field of the permanent magnet and the currents generated in it furnish a very good damping effect. On account of the fact that an ammeter and voltmeter of this type have practically the same structure, it is possible to make a very satisfactory combined ammeter and voltmeter from a single instrument, that is, the instrument itself is a milli-voltmeter and for measuring current, the milli-voltmeter measures the drop across a shunt, this drop of course being proportional to the current flowing in the shunt. For measuring voltage, it is only necessary to connect in series with the milli-voltmeter a series resistance of whatever amount is required for the voltage under measurement. (Figs. 3562-3.)

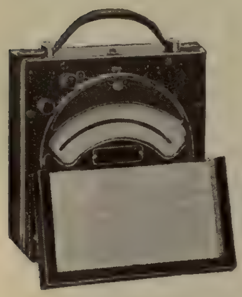


Fig. 3535. Portable Instrument. Milli-volt-ammeter.

Fig. 3536. Testing Instrument. Cover Removed. Voltmeter, Wattmeter or Ammeter.

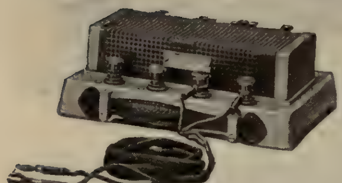


Fig. 3537. Portable Shunt for Milli-volt-ammeter.

GENERAL ELECTRIC ALTERNATING CURRENT INSTRUMENTS.

Alternating current instruments have considerably higher internal losses as it is necessary to furnish all of the energy to operate them. The most satisfactory instruments for alternating current voltmeters and wattmeters are known as the dynamometer type, that is, the construction consists of a set of stationary coils and a moving coil and the armature. This type of instrument is very accurate on alternating current and can also be used on direct current although it is not as accurate as the D'Arsonval type for direct current work. On account of the high resistance of the windings, the dynamometer type of instrument cannot very well be used as a combined ammeter and voltmeter. For alternating current ammeters, the most satisfactory type is the iron vane instrument where the current passes through a stationary coil and exerts a turning influence on a vane placed on the shaft. (See Fig. 3561.)

One other type of alternating-current instrument, which is probably better for low voltage signal testing than the dynamometer type of instrument, is the hot wire instrument. This type instrument has a very fine silver platinum wire, through which the current to be measured, or a shunted portion of it, is passed. The current heats the wire and a spring takes up the expansion, and, through a small pulley and a flexible connection, a turning moment is given the shaft, resulting in an indication proportional to the current passing through the platinum wire. This instrument can be made for a full scale current of about ¼ ampere and low-range voltmeters down to five volts can be made for this full-scale current. With the dynamometer type of instrument, it is not possible to make a satisfactory instrument of this voltage, which has a full-scale current less than about one ampere. Unlike the D'Arsonval type which takes a current proportional to the reading on the scale, alternating current instruments take a current proportional to the square of the current. That is, the current necessary for one-half scale deflection is one-quarter of the amount necessary for full scale deflection. It is possible, with the hot wire instrument, to furnish a combined ammeter and voltmeter by furnishing series resistance for different voltages and external shunts for different current capacities. (Fig. 3563.) These instruments can also be used on direct current, although they do not show polarity and have much higher losses than the D'Arsonval type. These losses are about in proportion to 10:1; that is, the hot wire taking 0.25 ampere for full-scale deflection and the D'Arsonval taking .025 ampere for full-scale deflections.

GENERAL ELECTRIC ELECTROSTATIC GROUND DETECTORS.

The electrostatic ground detector is practically an electrostatic voltmeter operating on the same principle as the quadrant electrometer, that is, it is based on the electrostatic attraction and repulsion of a set of stationary and moving vanes. The ground detector is used to indicate grounds on a single or polyphase a. c. circuit. This instrument, however, cannot be relied upon absolutely, in that a zero indication may not necessarily mean that the line is perfectly insulated. This is owing to the fact the instrument can be considered as a differential voltmeter measuring the difference in insulation resistance between the two sides of the line and the ground. If both sides are perfectly insulated, it will show zero. If both sides have a partial ground of equal resistance, it will still show zero indication. If one side of the line should be of lower insulation resistance than the other, the indication would show on the low side. In case of a ground on one side, the instrument will immediately indicate full voltage, the needle pointing toward the line or the phase which is grounded.

Fig. 3538. Testing Instrument.

Fig. 3539. Direct-Reading Ohmmeter. Queen & Company.

QUEEN DIRECT READING OHMMETER.

This instrument is arranged to measure unknown resistances directly upon a calibrated scale without calculation or reference to a table of values. The principle is that of the slide wire, but by means of multipliers of 1, 10, 100, 1,000 and 10,000 the range and accuracy of this instrument is greater than that of a slide wire bridge of the ordinary type. To use the instrument it is only necessary to place the unknown resistance in the binding post marked "line" and rotate the index until a balance is obtained. The unknown resistance is then read directly from the scale. If the multiplier is not on "1," the scale reading must be multiplied by the proper factor. A high-grade pivot and jewel D'Arsonval galvanometer forms a part of the instrument. The keys "BA" and "GA" are for closing the battery and galvanometer circuits, respectively. The

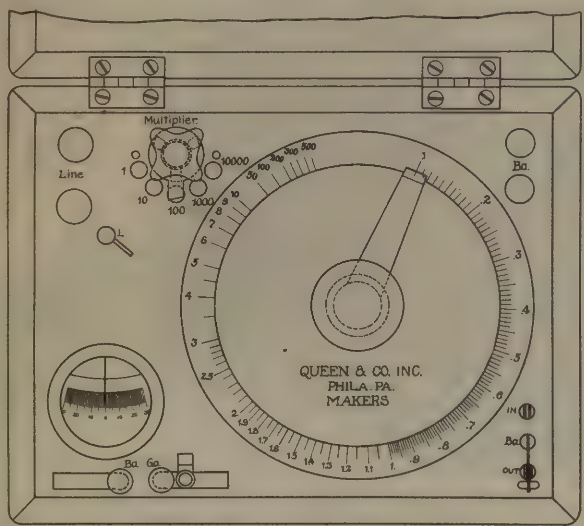


Fig. 3540. Direct Reading Ohmmeter. Queen & Company.

switch "BA" must be placed at "in" when using the contained battery, but if the internal battery is exhausted, an external battery of two ordinary dry cells can be connected to the post "BA" and used by placing the switch at "out." The small lever "L" is used to control the galvanometer at zero.

The instrument is balanced by determining when the galva-

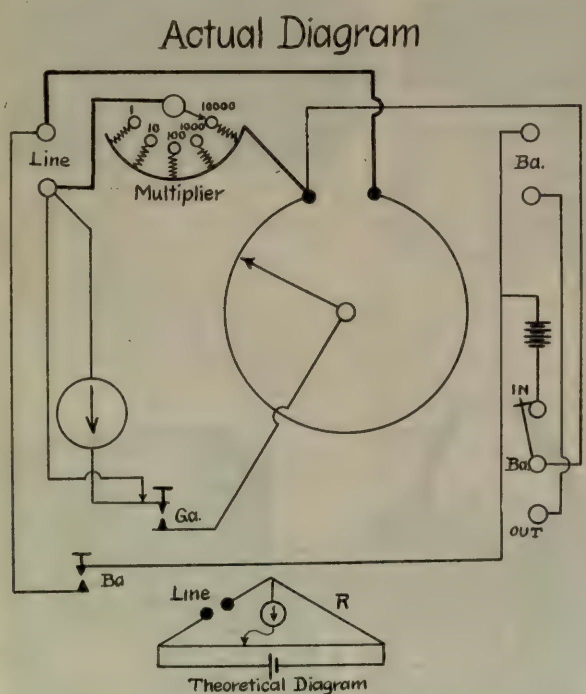


Fig. 3541. Diagrams of Circuits of Fig. 3556.

nometer does not deflect upon balancing the circuits. It is not essential that the galvanometer needle stand exactly at zero on the scale. Due to some amount of "shift" in the galvanometer, the lever "L" is used to return the needle to zero.

UNIVERSAL DUPLEX TESTING INSTRUMENT.

Fig. 3568 shows the Universal Duplex testing instrument made by the Bryant Zinc Co. The case is fitted with a lock and strap handle. There are two separate deadbeat D'Arsonval movements, which are fitted with jewel bearings. The voltmeter has six scale values and the ammeter has five scale values. There are but two binding posts used for each meter. The unique feature of the instrument is the arrangement of plugs, by means of which any scale on either meter can be used without moving any wires. The length of each scale is three inches. They are divided into 30 divisions, which are one-tenth of an inch apart, for quick reading, where the current and voltage are continually changing when testing the

Fig. 3542. Universal Duplex Testing Instrument.

operating current, as of a signal. With the one-tenth inch divisions it is easy to follow the different values of current and voltage while the signal is making a clearing movement.

There are both voltage and current scales, designed for the rapid and accurate testing of track circuits, relays, indicators, slots and power interlocking.

To determine the clearing and holding current of a signal with this instrument, the operation is as follows:

Insert one plug in the 30-milli-ampere block and one plug in the three-ampere block. When the circuit is closed, the

Figs. 3543-3544. Counter for Signals. Veeder Manufacturing Company.

meter will indicate amperes on the three-ampere scale. When the signal is in the clear position, the needle drops back to very nearly zero. If now the plug in the three-ampere block is removed, the instrument will indicate in milli-amperes the amount flowing through the slot coils. This test is made without disturbing slot wires on signal or wires on instrument.

The two ammeter posts are connected directly to the galvanometer movement. This makes it possible to use additional shunts reading 0 to 30, 90, 120 amperes, etc., if desired. In using external shunts, it is only necessary to remove the ammeter plugs and connect shunt to the two posts.

POTENTIAMETER RHEOSTAT.

Fig. 3571 shows the Potentiameter rheostat made by the Bryant Zinc Co.

This instrument is used for testing the operating and releasing current of relays, locks, slots, indicators, etc., which devices in many cases operate on very small amounts of current. In a range of resistance from 2 to 2,000 ohms, this instrument will allow regulation to be made to in fractions of a milli-ampere.

T he double-pole, double-throw switch will allow tests to be made in connection with polarized circuits and to determine the value or amounts of residual magnetism.

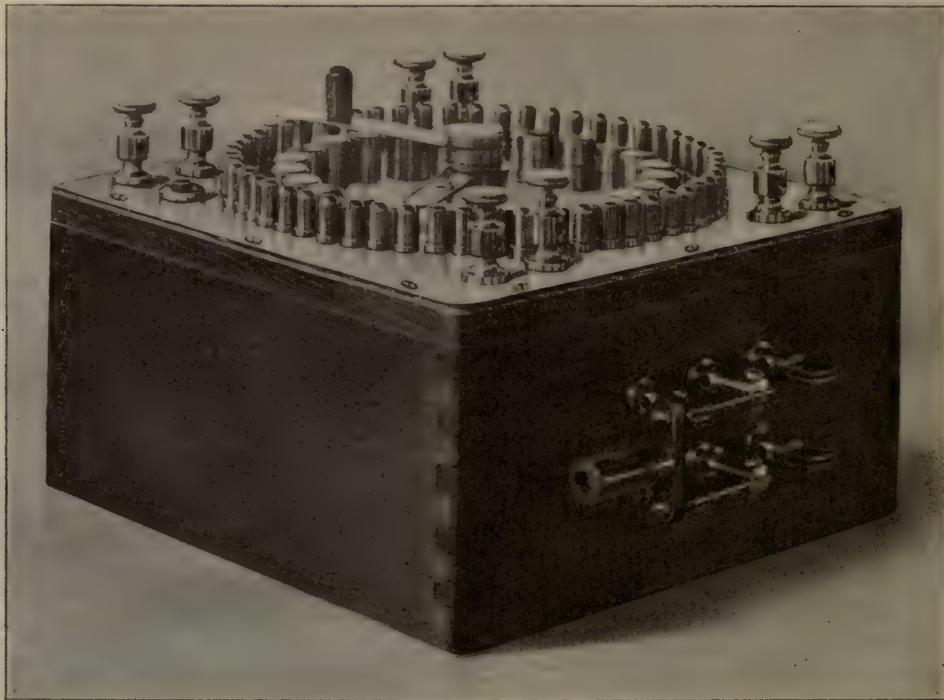


Fig. 3545. Potentiameter Rheostat. Bryant Zinc Company.

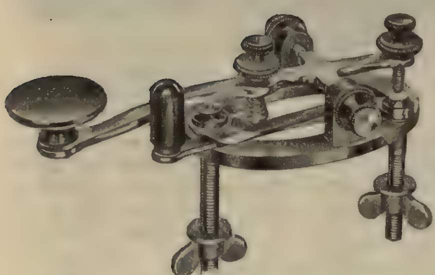


Fig. 3546. Telegraph Key.

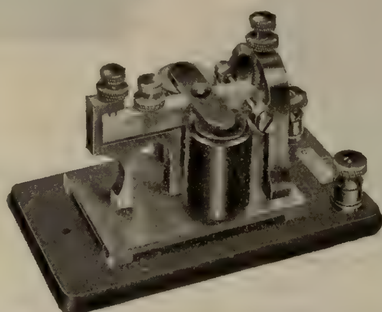


Fig. 3547. Telegraph Sounder.

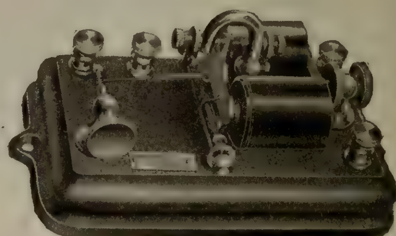
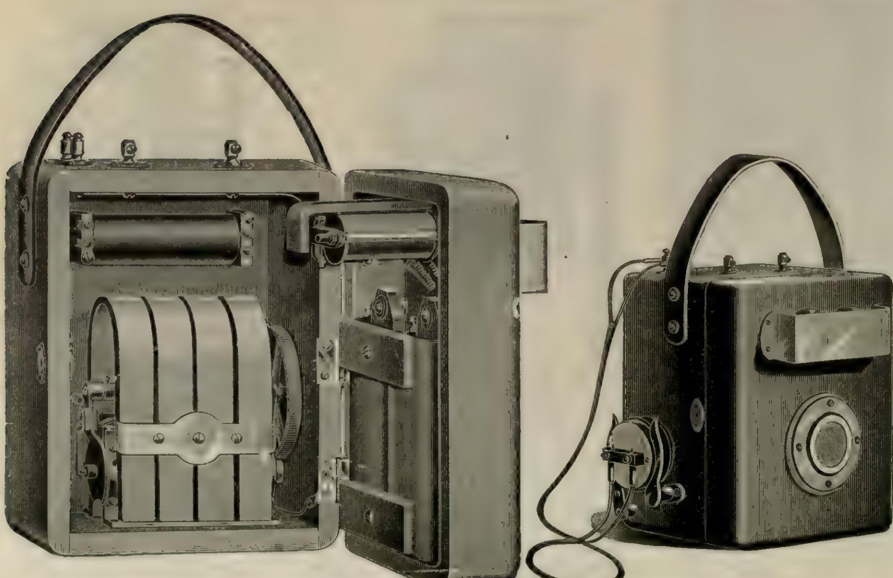


Fig. 3548. Telegraph Relay.

Figs. 3546-3548. Telegraph Instruments. Western Electric Company.



Figs. 3549-3550. Magneto Testing Set with Telephone.

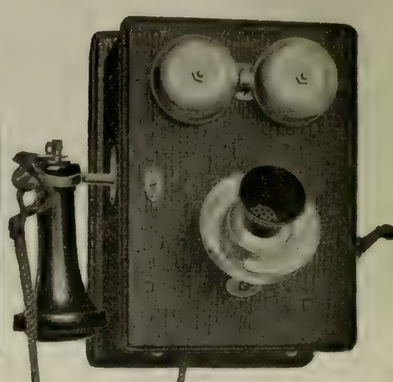


Fig. 3551. Telephone Wall Set. Western Electric Company.

Fig. 3552. Multipliers for Portable Volt-meters. Weston Electrical Instrument Company.

Fig. 3553. Pocket Track Circuit Tester.

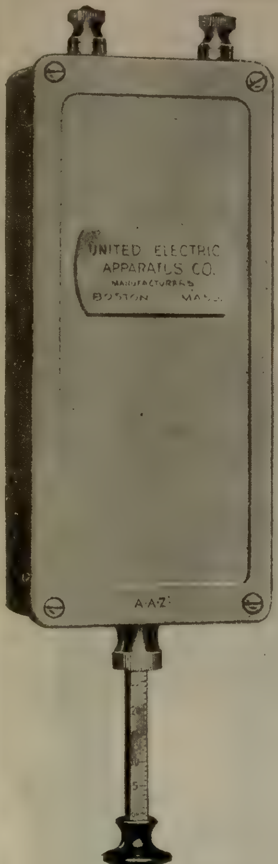


Fig. 3554. Adjustable Resistance Testing Box.

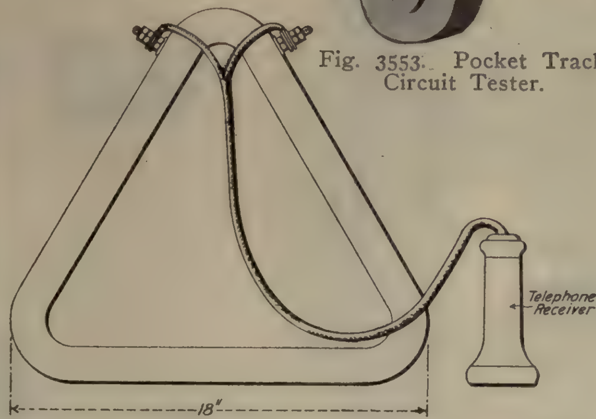


Fig. 3555. Exploring Coil for Alternating Current Track Circuit.

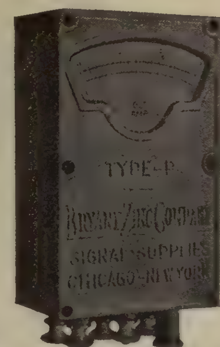


Fig. 3556. Pocket Volt-Ammeter. Bryant Zinc Company.

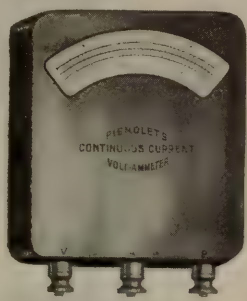


Fig. 3557. Portable d'Arsonval Type Voltmeter. Louis M. Pignolet.

Fig. 3558. A. C. and D. C. Voltmeter. Louis M. Pignolet.

TOOLS AND APPLIANCES

MAINTENANCE

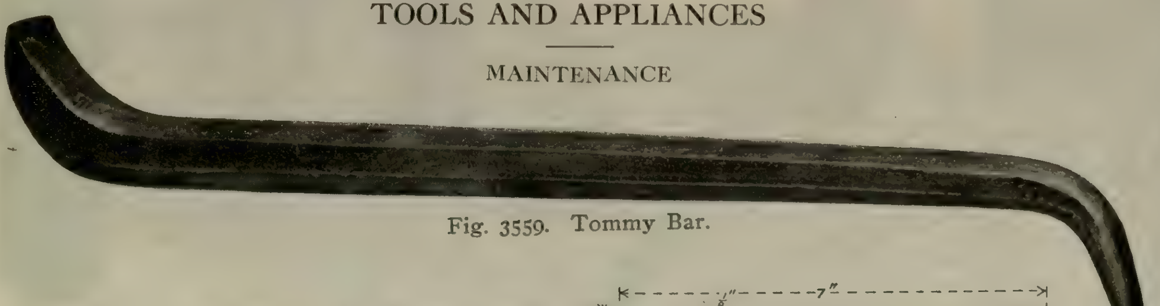
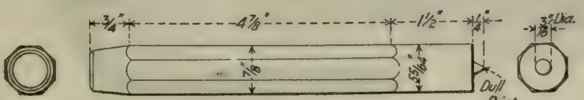


Fig. 3559. Tommy Bar.



Figs. 3560-3561. Lock Rod Center Punch.

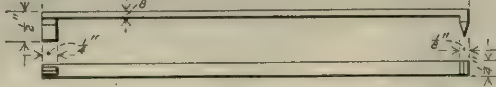


Fig. 3562. Special Screw Driver for Building Posts, Etc.

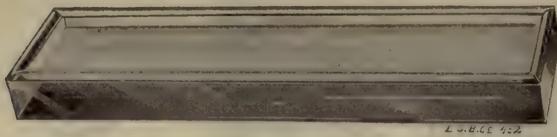


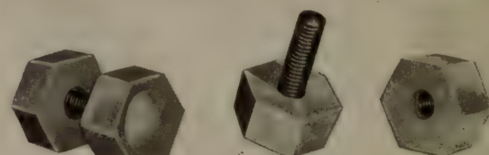
Fig. 3563. Glass Hold-Down for Separators. "Chloride Accumulator."

TRACK CIRCUIT TESTER.

This instrument was designed for the use of signalmen in testing for track circuit troubles. It comprises an iron-clad electromagnet wound to four-ohms resistance, with an easy working armature, all of which are covered by a brass shield, with substantial binding posts, flexible wires and metal terminals. The instrument is shown in Fig. 3576.

Fig. 3564. Type "E" Wood Separator, for "Chloride Accumulator."

Fig. 3565. Type "E" Wood Separator for "Tudor Accumulator."



Figs. 3570-3572. Bolt Connectors. "Chloride Accumulator."

Fig. 3567. Type "B" Hydrometer.

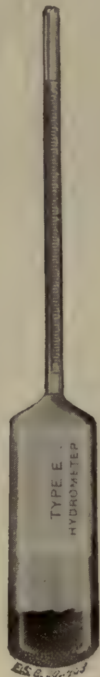


Fig. 3568. Type "E" Hydrometer.

Figs. 3567-3568. Storage Battery Hydrometers. Electric Storage Battery Company.

Fig 3566. Battery Hydrometer.

Fig. 3569. Hydrometer Syringe (Specific Gravity Tester, for Portable Cells).

Fig. 3573. "Solderall" Pocket Torch.

Figs. 3574-3575. Battery Cleaning Brush and Knife.

Fig. 3576. Track Circuit Tester. Bryant Zinc Company.

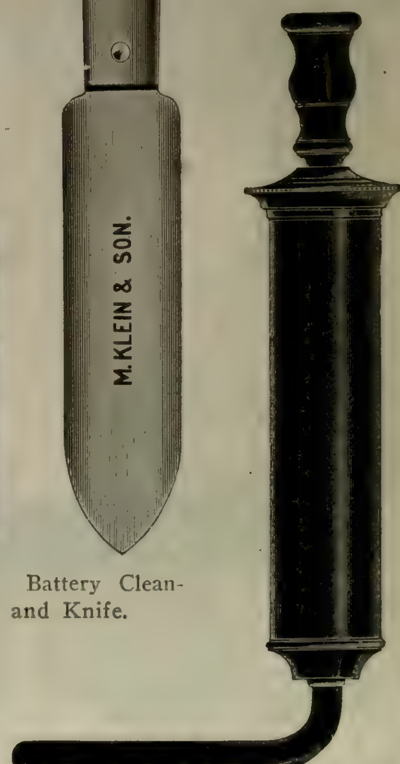


Fig. 3577. Battery Syringe.

MOTOR CARS

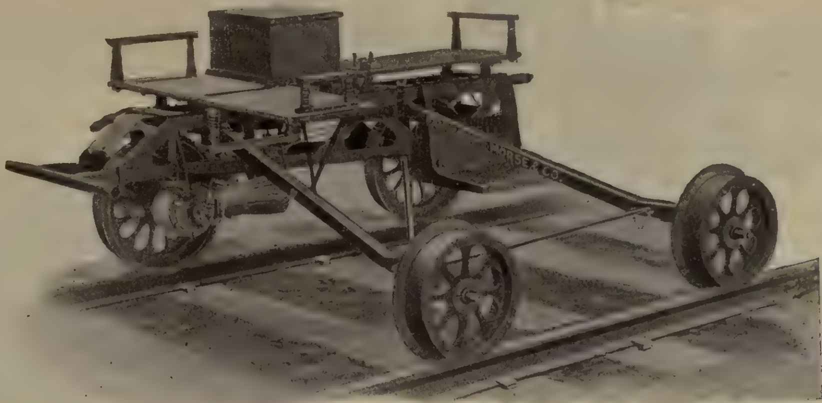


Fig. 3578. No. 28 Gasoline Motor Car (All Steel). Fairbanks, Morse & Co.

FAIRBANKS MORSE MOTOR CARS.

The No. 28 motor car made by Fairbanks, Morse & Co. has a pressed steel frame and a two-cycle, two-cylinder, air-cooled engine, one cylinder being direct connected to the front axle on each side. The cylinders are 3¼ in. by 4 in., and the cranks are entirely enclosed. The engine is lubricated by oil mixed with the gasoline, which passes through the carburetor. The car weighs 400 lbs., seats three persons, and will develop speeds up to 30 miles an hour.

The No. 28 car made by Fairbanks, Morse & Co. has a two-cylinder, two-cycle, air-cooled engine back geared 2 to 1 to the front wheel, developing 2¾ h. p. The cylinders are three inches in diameter. The car has spark and throttle control and an automobile float feed carburetor. The car weighs 320 lbs. and operates safely at speeds up to 20 miles an hour.

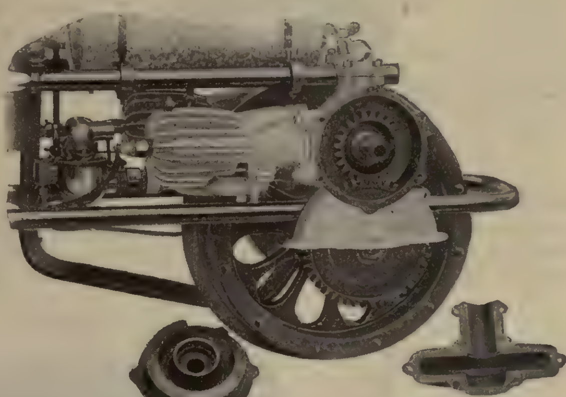


Fig. 3579. Showing Motor Car Engine and Driving Gear of No. 30 Car. Fairbanks, Morse & Co.

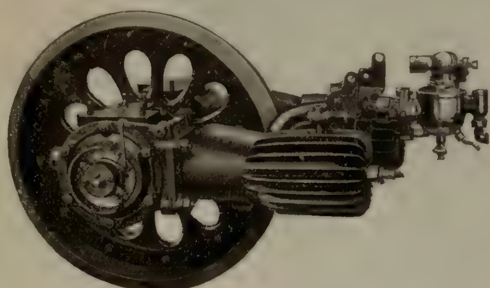


Fig. 3580. Showing Timer Side of No. 28 Car. Fairbanks, Morse & Co.

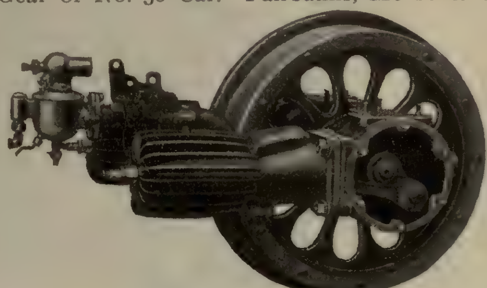


Fig. 3581. Showing the Crank Case of No. 28 Car. Fairbanks, Morse & Co.

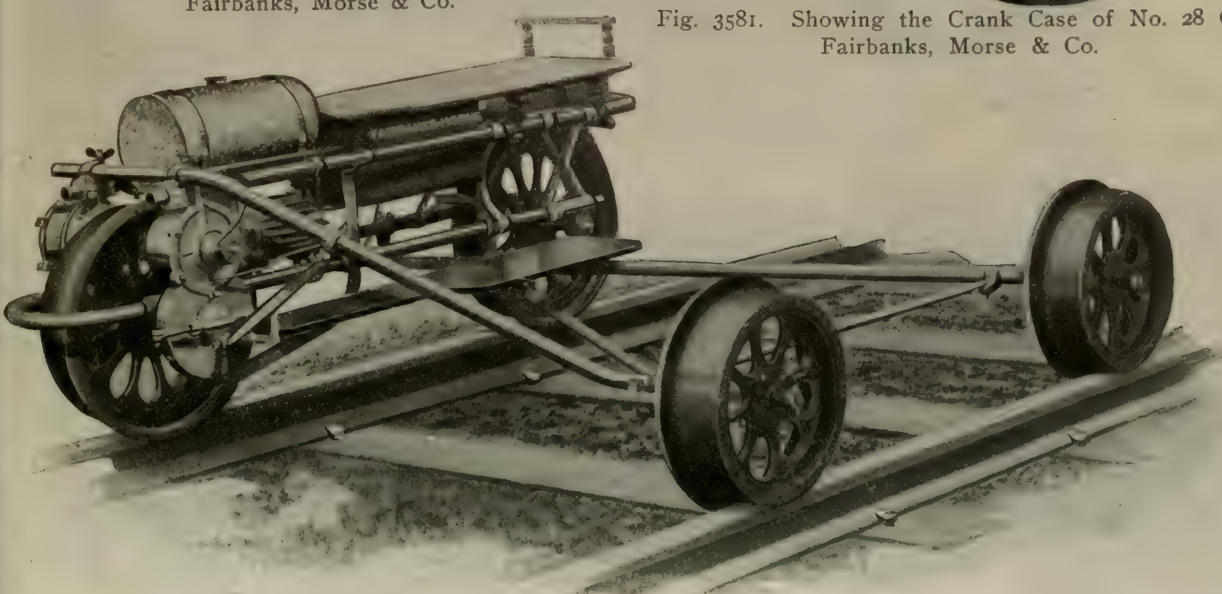


Fig. 3582. No. 30 Gasoline Motor Car (All Steel). Fairbanks, Morse & Co.

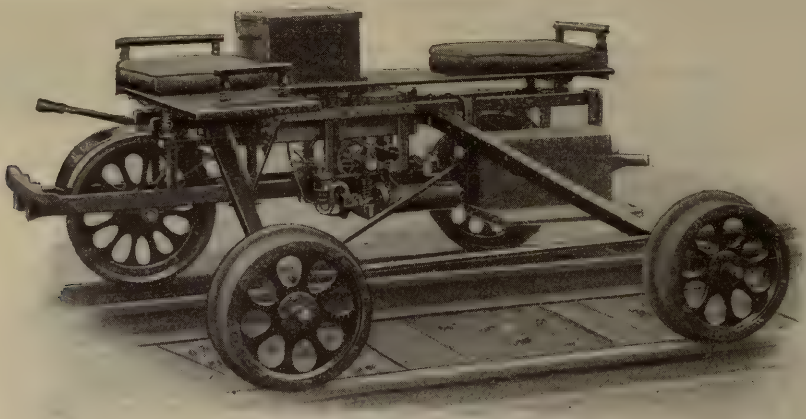


Fig. 3583. 2J Gasoline Motor Car. Fairbanks, Morse & Co.

Motor Car No. 30 made by Fairbanks, Morse & Co. has a steel tubing frame and a two-cylinder, two-cycle, three-part, air-cooled engine with 2¾ in. by 3 in. cylinders, geared direct to the driving axle. The engine has the automatic lubrication provided on Car No. 28. The car will seat one or two persons, runs at speeds up to 25 miles an hour and weighs 320 lbs.

ADAMS MOTOR CAR.

The Adams Motor Car, made by Burton W. Mudge & Co., is of the direct connected four-wheel type. The frame is built of six white ash rails bolted together and braced and reinforced at joints and wearing points. The engine is a 4½ h. p. two-cycle, two-port, air-cooled single cylinder motor, direct connected to the rear wheel and having three moving parts, the piston, connecting rod and crank shaft all enclosed. The ignition is jump spark, the battery, spark coil and switch being enclosed in a locked box built into the frame of the car. The oiling is accomplished by mixing the lubricating oil with the gasoline. Special provision is made by a grease cup on the crank case for lubricating the main bearings, and the crank pin bearings. The car can be used with three or four wheels, but the four-wheel type is standard. The body wheels are 17 in. in diameter, and the guide wheels 14 in. The equipment includes one socket wrench for the engine, one combination wrench and a book of instructions. Figs. 3584-3585 show the Adams Motor Car.

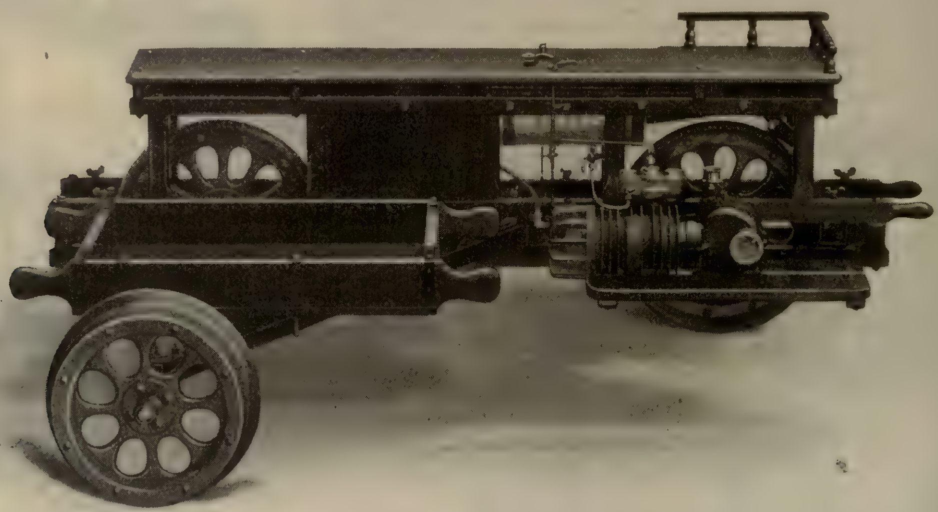


Fig. 3584. Adams Motor Car. Rear Wheel Cut Away to Show Engine and Tool Tray. Burton W. Mudge & Company.

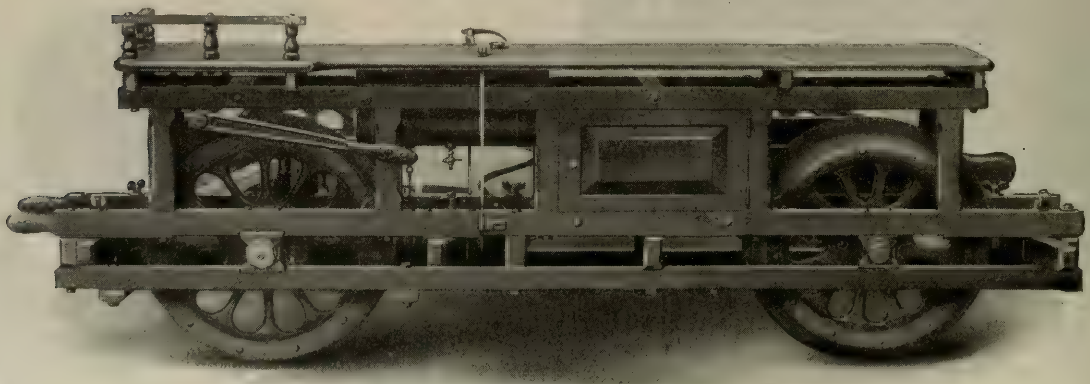


Fig. 3585. Adams Motor Car. Burton W. Mudge & Company.

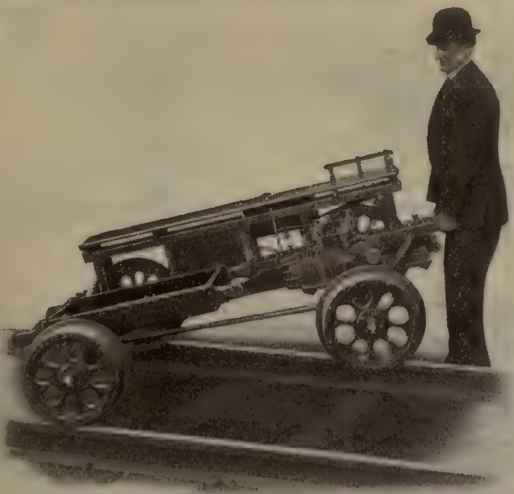


Fig. 3586. Adams Motor Car.

BUDA MOTOR VELOCIPEDES.

Motor velocipede cars are made by The Buda Co. in both three and four-wheel styles, and designed to carry from one to three persons. The two lower sills of the frame which carries the

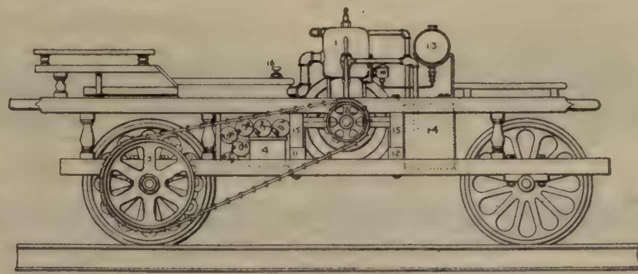


Fig. 3587. Velocipede Motor Car Fitted with Belle Isle Engine. Concrete Form & Engine Company.

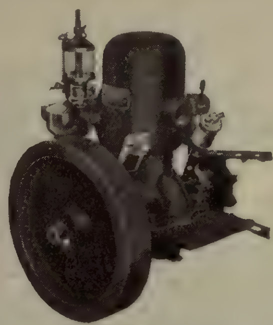


Fig. 3588. Belle Isle Gasoline Engine. Concrete Form & Engine Company.

Fig. 3589. No. 12A Four-Wheel Motor Velocipede. The Buda Company.

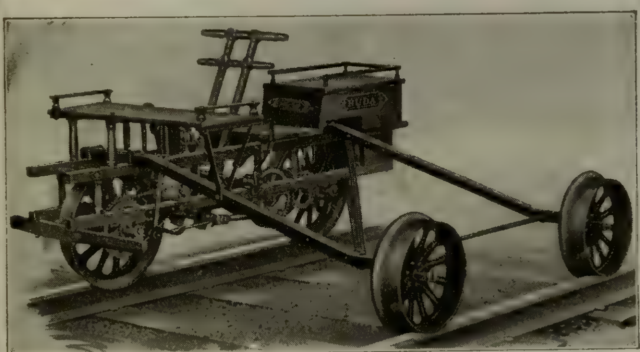


Fig. 3590. Four-Wheel Motor Velocipede. The Buda Company.

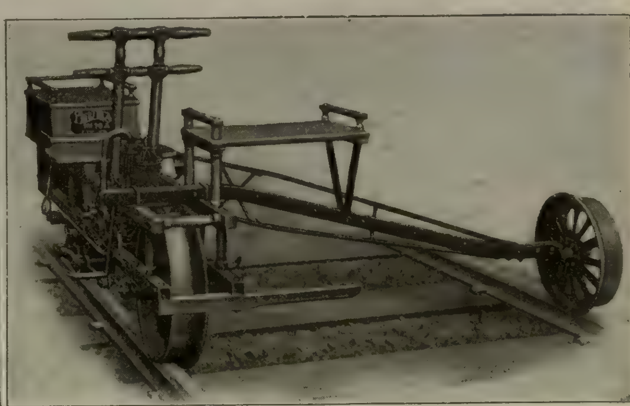


Fig. 3591. Three-Wheel Motor Velocipede. The Buda Company.

engine are of square steel tubing, the upper sills are of wood, and the guide arm is also of wood re-enforced by riveted iron straps. The diagonal brace connecting the guide arm and the frame is of channel iron. The brace is swiveled at the guiding wheel.

The engine is of the four-cycle type, air cooled. Six types of these cars are equipped with 2¼ h. p. engines, and one type of four-wheel car for three persons with 4 h. p. The cylinder is bored from a solid bar of steel. The exhaust valve is made of pure nickel, and the crank shaft is enclosed in an aluminum casing. The engine is lubricated by the splash system. The equipment of the car includes a waterproof spark coil and a duplicate set of batteries. The gasoline tank holds a supply for about 200 miles.

The Buda cars are driven through the front wheel by a sprocket wheel attached to it by a friction arrangement to prevent breaking the chain or damaging the engine in case of a too sudden start or a derailment. The wheel base of the car is 46 in., the axles are of steel, the wheels have brass bearings. The main wheels are 17 in. and the guide wheels 14 in. in diameter. The speed can be regulated from three to 30 miles an hour. All types of cars may be fitted with a tray for carrying batteries or lamps.

ROCKFORD INSPECTION MOTOR CARS.

The Rockford inspection motor cars made by the Chicago Pneumatic Tool Co. are four-wheel cars and will carry from one to three persons. The car frames are of welded steel channels and angles. A two-cylinder, four-cycle, air-cooled engine direct connected to the driving axle and developing 3¼ h. p. is used. The equipment of the car includes a six-cell multiple series battery with a double waterproof spark coil and timing and control levers operating on a spark and throttling the fuel supply. The gasoline tank, located under the seat of the car, will carry a fuel supply for 100 miles. The driving wheels are 17 in. in diameter and the guide wheels 14 in. A speed of from three to 20 miles an hour may be maintained. The No. 2 car weighs 375 lbs.

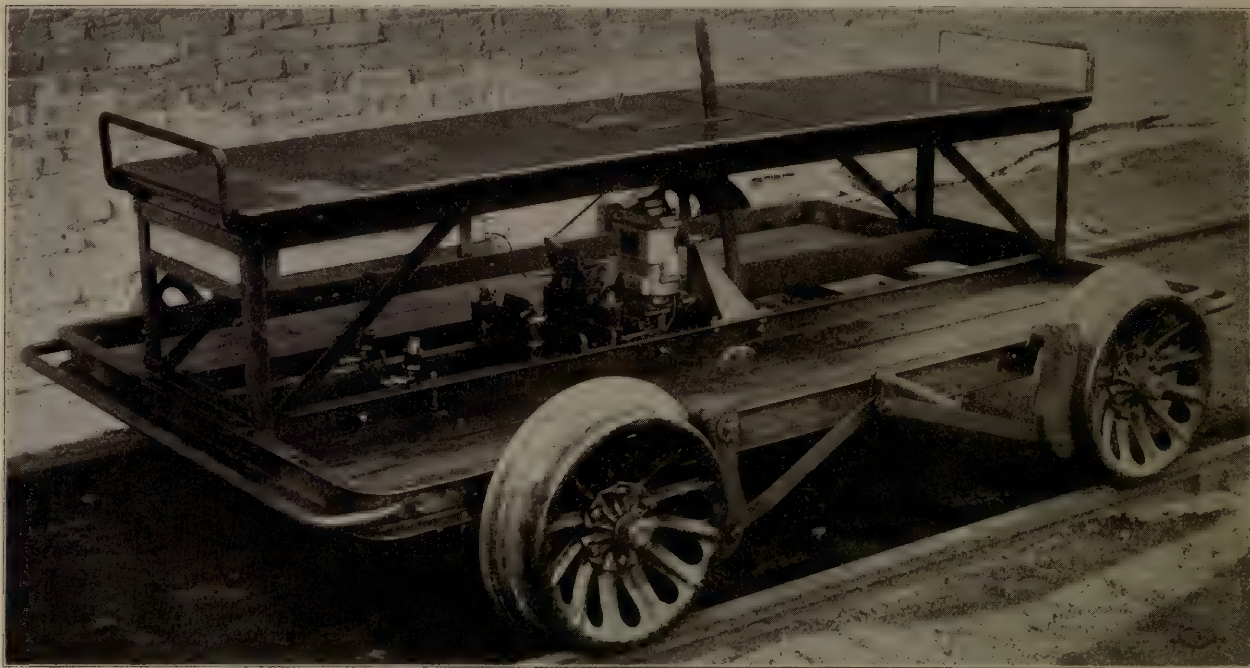


Fig. 3592. No. 4 Rockford Section Motor Car. Chicago Pneumatic Tool Company.

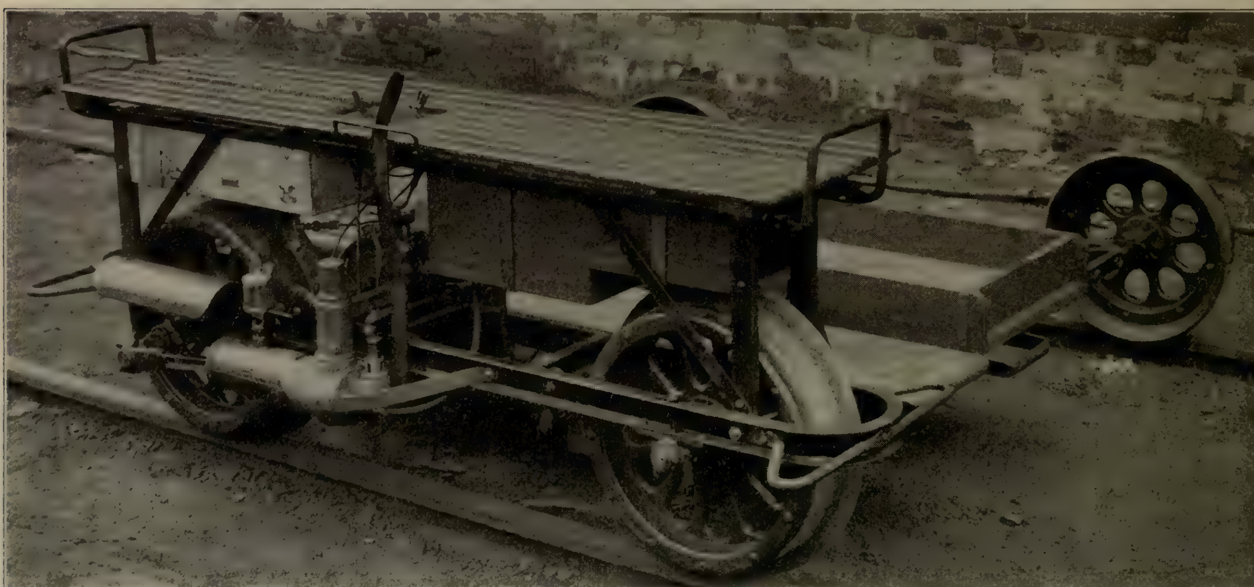
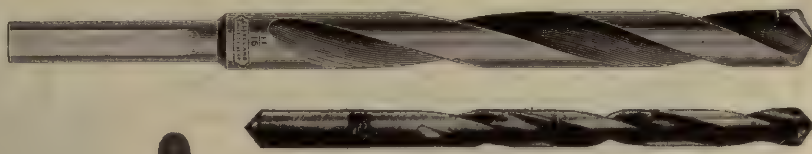


Fig. 3593. No. 2 Rockford Signal and Lineman's Car. Chicago Pneumatic Tool Company.

TRACK CIRCUIT AND BONDING TOOLS

Fig. 3594. Bond Wires in Bundle.



Figs. 3595-3596. Twist Drills for Bonding.

Machine Fitted to Drill Base of Rail.

Machine Fitted to Drill Web of Rail.

Figs. 3597-3598. Drilling Machine for Rail Bonding. The Union Switch & Signal Company.

Fig. 3599. Chuck for Drilling Machine. Railroad Supply Company.

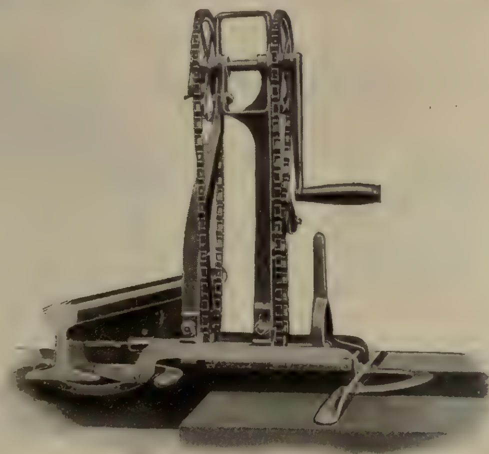


Fig. 3600. Buda Wilson Drill. Under Clutch. The Buda Company.

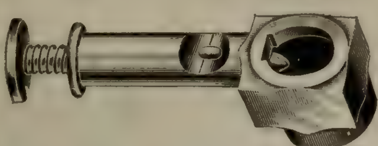


Fig. 3604. Channel Pin Gauge. Bryant Zinc Company.

Figs. 3602-3603. Channel Pin Set and Punch. Bryant Zinc Company.

Fig. 3601. Buda Wilson Drill. Hook Over Top of Drill. The Buda Company.

Fig. 3605. Channel Pin.

Fig. 3606. Small Channel Pin Drift Punch.

Fig. 3607. Channel Pin Set.

Fig. 3608. Channel Pin Drift Punch.

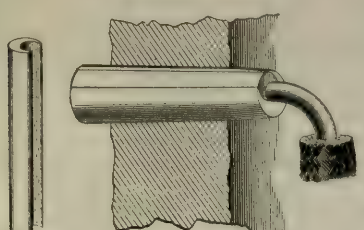
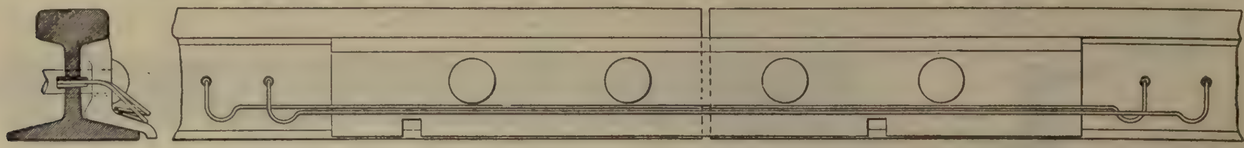


Fig. 3609. "Boot Leg" Channel Pin and Bond Wire in Rail. Railroad Supply Company.



Figs. 3610-3611. Bond Wires Outside of Splice Bars; Fastened by Bonding Tubes.

Fig. 3612. Bond Wire Behind Splice Bar; Fastened by Rivets.

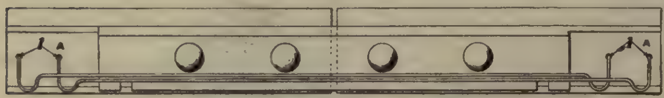
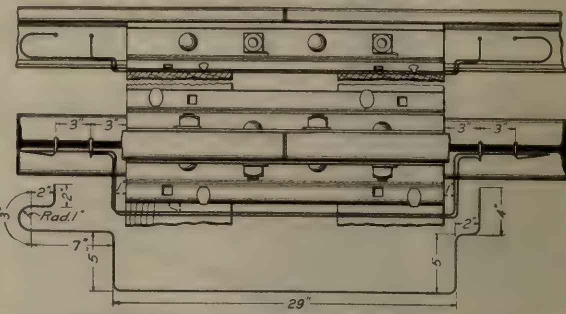


Fig. 3613. Bond Wires Outside of Splice Bar; Fastened by Channel Pins.



Figs. 3616-3618. Standard Rail Bond. Oregon Short Line.

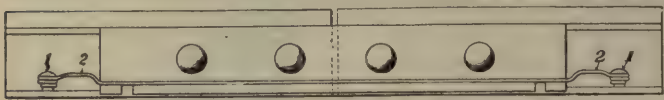


Fig. 3614. Bond Wire Outside of Splice Bar; Fastened by Rivets.

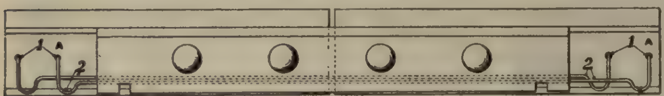
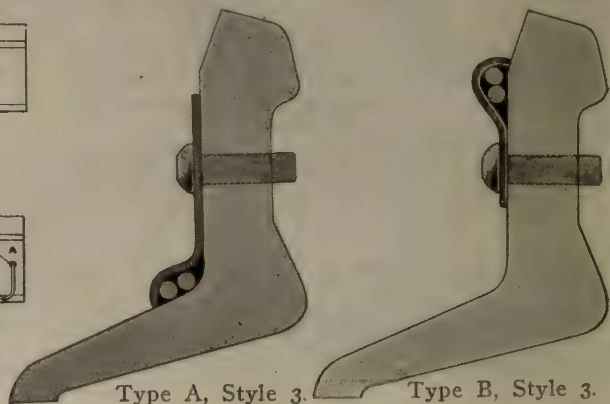


Fig. 3615. Bond Wires Behind Splice Bar; Fastened by Channel Pins.

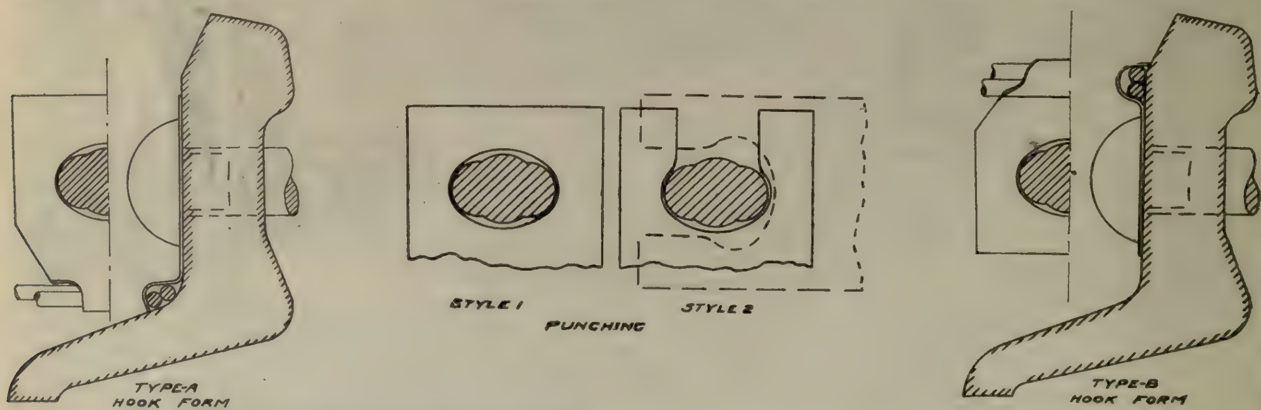


Type A, Style 3. Type B, Style 3.

Figs. 3619-3620. Bond Wire Protectors. P. & M. Company.

P. & M. BOND WIRE PROTECTORS.

The P. & M. Co. makes three styles of bond wire protectors, each of which has two types, one holding the wires below the track bolt and the other above. The protectors holding the wires below the bolts are best adapted for use where the bond wires are applied on the gage side of the rail and the flange clearance is not great enough to allow the wires to be placed above the bolts. Style 1 has an elliptical hole, which fits snugly over the neck of the bolt, and is best suited for use on new work or when renewing track bolts, as it must be applied over the end of the bolts. Style 2 is designed to be applied without entirely removing the bolts. The elliptical hole provided in Style 1 is slotted to slip over the smaller dimension of the bolt neck, being held firmly in place when rotated 90 degs. Style 3 is designed for application independent of the track bolt and, therefore, can be used both for bond wires and boot-leg connections. It is held in place by a 9-32-in. rivet, driven in a hole drilled with a 9-32-in. bonding drill.



Figs. 3621-3626. Bond Wire Protectors Showing Methods of Application. P. & M. Company.

Fig. 3627. Type B, Style 1, Bond Wire Protectors in Service. P. & M. Company.

TRACK AND PIPE LINE INSULATION

KEYSTONE INSULATED RAIL JOINTS.

The special feature of the Keystone insulated rail joint is that there is a metal filler under the rail head, which increases the area of insulating material, and receives the shock from passing trains.

The filler and angle bar are of rolled steel. The angle bar section is such that it makes the joint as strong to resist both vertical and horizontal stresses as is the non-insulated joint.

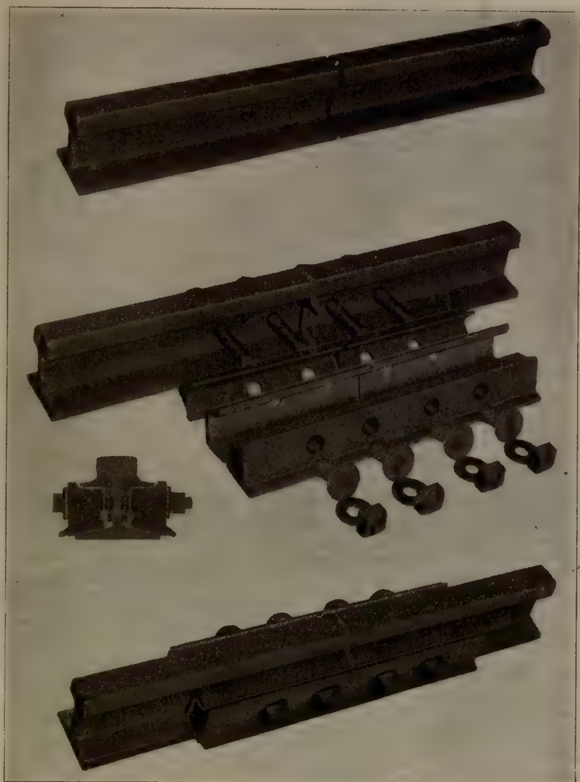


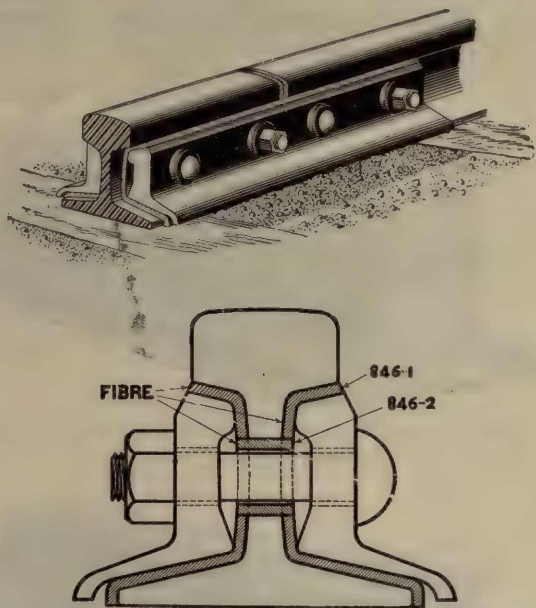
Fig. 3628. Keystone Rail Joint. The Union Switch & Signal Company.

the breaking of rails through the bolt holes at insulated joints is a more frequent occurrence with forms of joints that do not provide efficiently against the vertical movement of the rails with relation to each other.

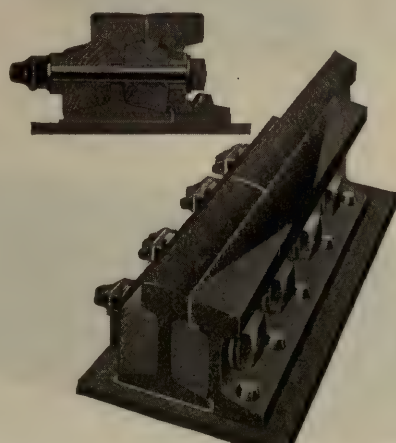
The only material used other than steel is insulating fibre, the area of which is such that the pressure per square inch upon it is low as compared to the pressure between the ordinary angle bar and the rail. This gives a rigid backing against which the bolts may be firmly tightened and remain so; and against which the shock of passing wheels does not settle the "running on" end of the rail nor allow the "running off" end to kick up, thereby wearing out the fibre.

The joint, when placed in a curve, bends to the rails like an ordinary angle bar so that the curve of the rail is uniform. It is applied like an ordinary angle bar and as no part of it goes between the base of the rail and tie, no dapping or lowering of the ties is required. Water and dirt do not work in between the fibre and the metal to cause an electrical break-down of insulation because there is no movement between the parts.

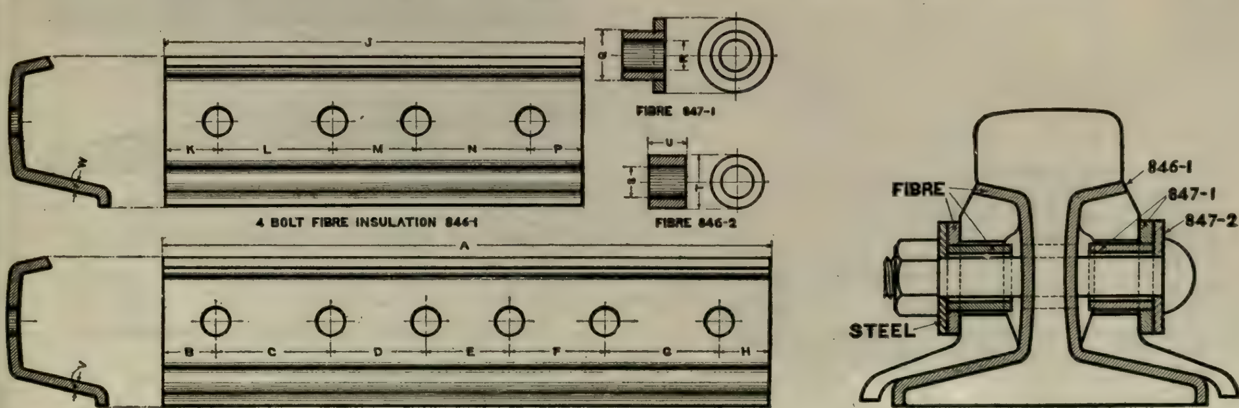
The Keystone insulated joint is illustrated in Fig. 3628. It is made by the Union Switch & Signal Company.



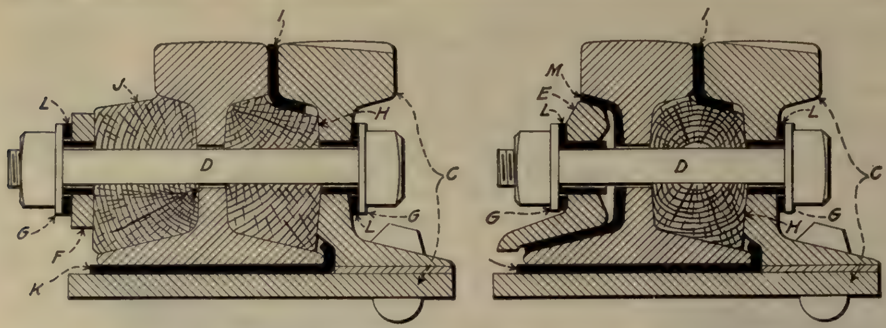
Figs. 3629-3630. Insulated Rail Joint. Railroad Supply Company.



Figs. 3631-3632. Mock Insulated Rail Joint. Buffalo Railway Supply Company.



Figs. 3633-3637. Insulated Rail Joint and Fibre Parts. Railroad Supply Company.

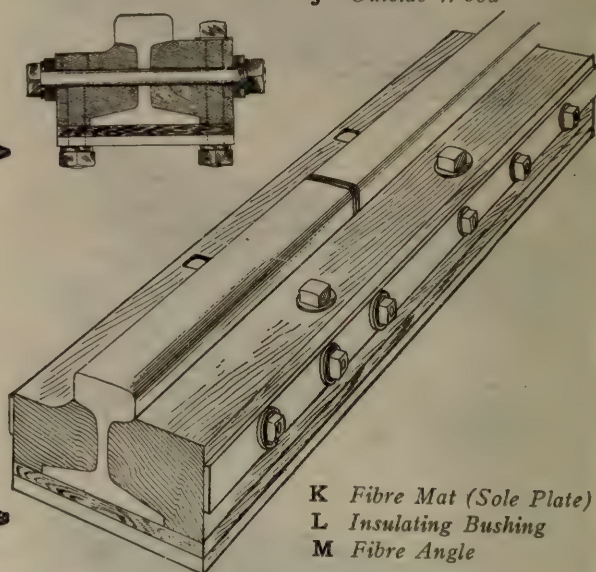


Figs. 3638-3639. Details of Mock Insulated Rail Joints.

Names of Parts of Mock Insulated Rail Joints; Figs. 3638-3639.

- **C** *Auxiliary Rail Riveted to Steel Plate and Filler*
- **D** *Bolt*
- **E** *Steel Angle Bar*
- **F** *Iron Strap*
- **G** *Iron Washer*
- **H** *Inside Wood*
- **I** *Fibre Strip*
- **J** *Outside Wood*

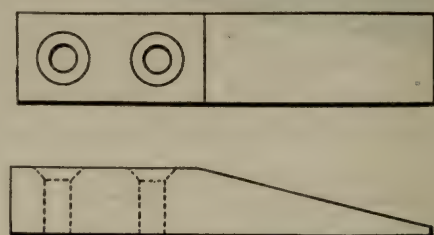
Fig. 3640. The "Continuous" Joint. The Rail Joint Company.



- **K** *Fibre Mat (Sole Plate)*
- **L** *Insulating Bushing*
- **M** *Fibre Angle*

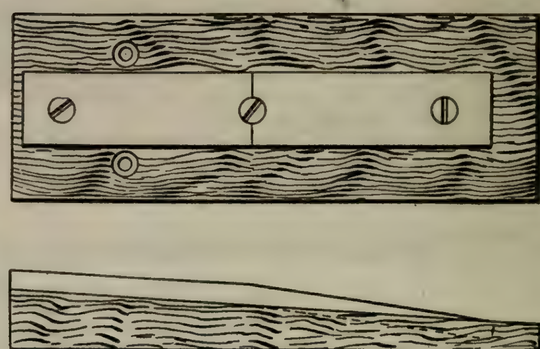
Figs. 3643-3644. Insulated Rail Joint. Railroad Supply Company.

Fig. 3641. The Weber Joint; Wooden Splices. The Rail Joint Company.

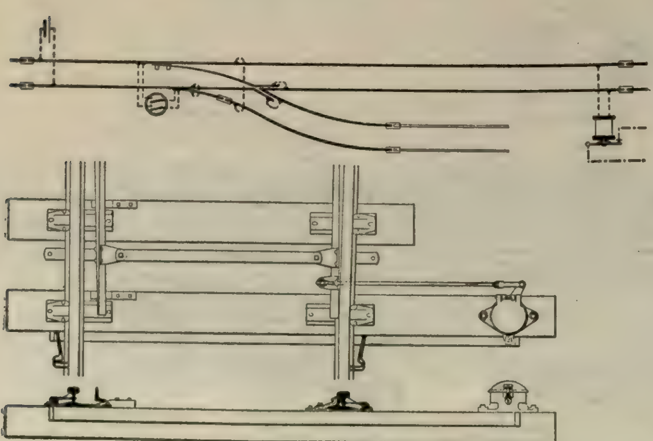


Figs. 3645-3646. Switch Wedge Countersunk for Wood Screws.

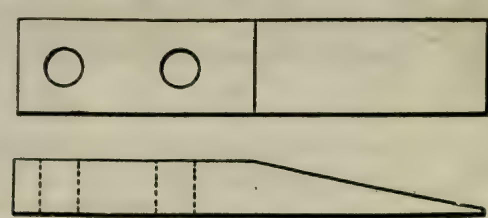
Fig. 3642. The Weber Joint; Steel Splices. The Rail Joint Company.



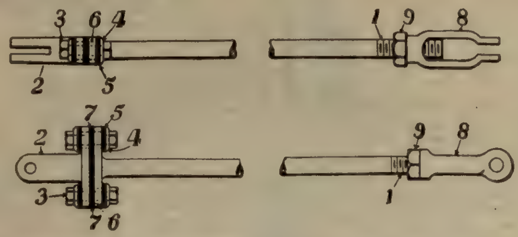
Figs. 3649-3650. Switch Wedge with Wooden Base.



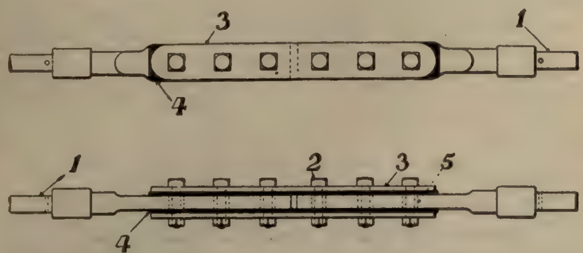
Figs. 3647-3648. Wedged Switch in Track Circuit.



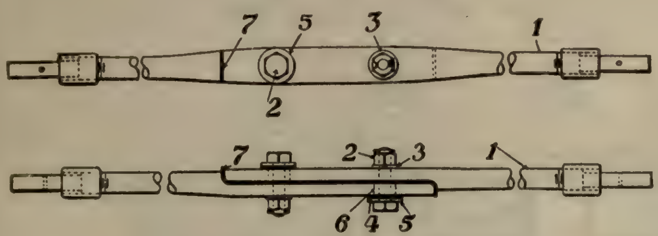
Figs. 3651-3652. Switch Wedge Drilled for Lag Screws.



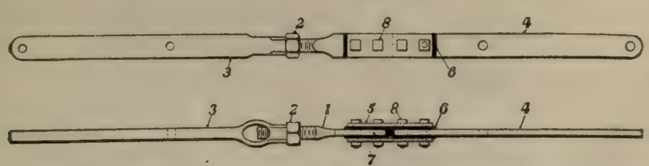
Figs. 3653-3654. Insulated Rod with Special Jaw for Rocker Shaft Connection. The Union Switch & Signal Company.



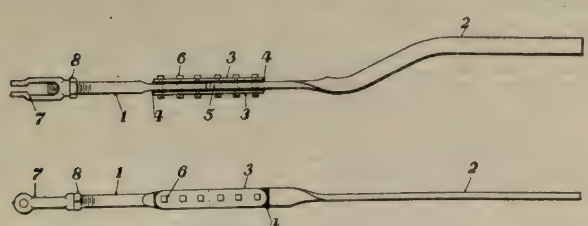
Figs. 3655-3656. Pipe Line Insulation.



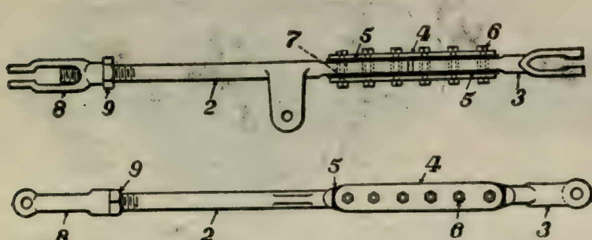
Figs. 3657-3658. Pipe Line Insulation.



Figs. 3659-3660. Adjustable Insulated Switch Rod. The Union Switch & Signal Company.



Figs. 3661-3662. Insulated Lock Rod.



Figs. 3663-3664. Adjustable Insulated Front Rod.

Names of Parts, Insulated Rod with Special Jaw; Figs. 3653-3654.

1 *Threaded Rod*
2 *Special "T" Jaw*
3 *Bolt and Nut*
4 *Steel Washer*
5 *Fibre Washer*
6 *Fibre Bushing*
7 *Fibre Plate*
8 *Screw Jaw*
9 *Jam Nut*

Names of Parts, Pipe Line Insulation; Figs. 3655-3656.

1 *Tang End*
2 *Bolt*
3 *Splice Plate*
4 *Fibre Plate*
5 *Fibre Bushing*

Names of Parts, Pipe Line Insulation; Figs. 3657-3658.

1 *Tang End*
2 *Bolt and Nut*
3 *Spring Washer*
4 *Fibre Washer*
5 *Wrought Washer*
6 *Fibre Bushing*
7 *Fibre Plate*

Names of Parts, Adjustable Insulated Switch Rod; Figs. 3659-3660.

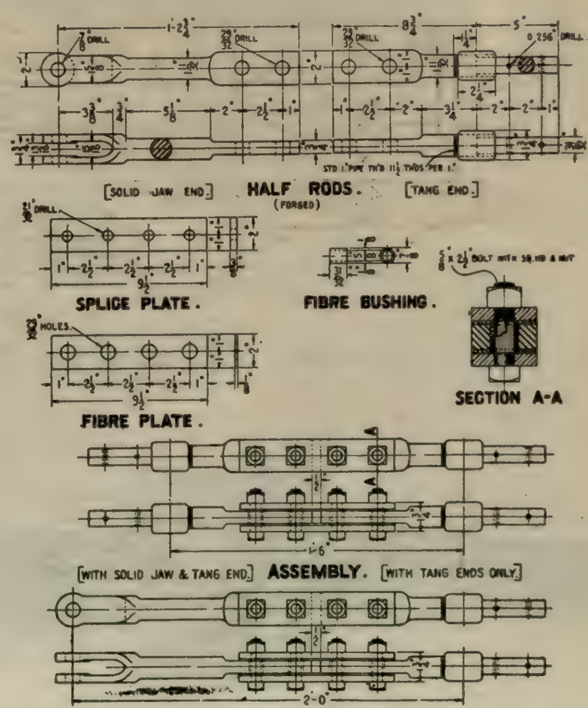
1 *Threaded Piece*
2 *Jam Nut*
3 *Socket Rod*
4 *Plain Rod*
5 *Splice Plate*
6 *Fibre Plate*
7 *Fibre Bushing*
8 *Bolt*

Names of Parts, Insulated Lock Rod; Figs. 3661-3662.

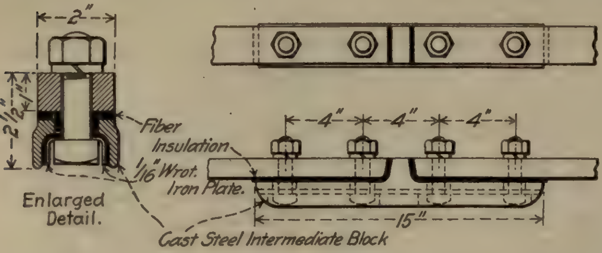
1 *Threaded Rod*
2 *Tappet*
3 *Splice Plate*
4 *Fibre Plate*
5 *Fibre Bushing*
6 *Bolt*
7 *Screw Jaw*
8 *Jam Nut*

Names of Parts, Adjustable Insulated Front Rod; Figs. 3663-3664.

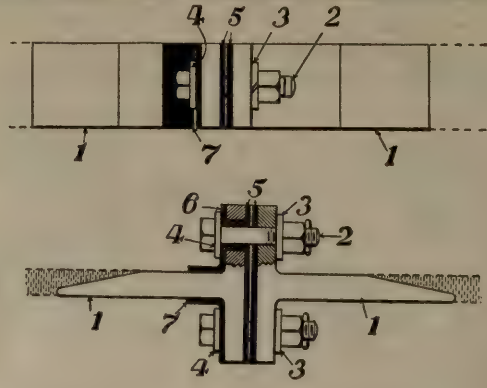
2 *Lug Rod*
3 *Solid Jaw*
4 *Splice Plate*
5 *Fibre Plate*
6 *Fibre Washer*
7 *Fibre Bushing*
8 *Screw Jaw*
9 *Jam Nut*



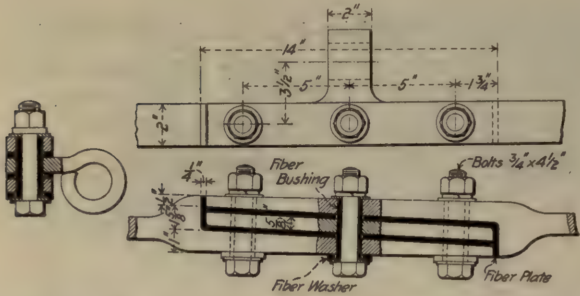
Figs. 3665-3674. R. S. A. Standard Pipe Line Insulation.



Figs. 3675-3677. Insulated Switch Rod and Details. Pennsylvania Railroad.



Figs. 3678-3679. Insulated Joint for Welding into Tie Plates, etc. The Union Switch & Signal Company.



Figs. 3680-3682. Insulated Switch Rod with Lug for Throw Rod. Pennsylvania Railroad.

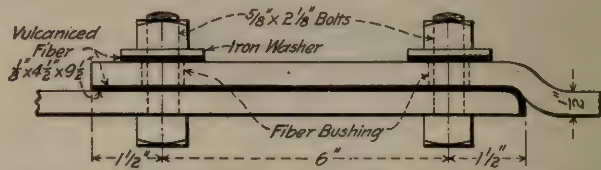
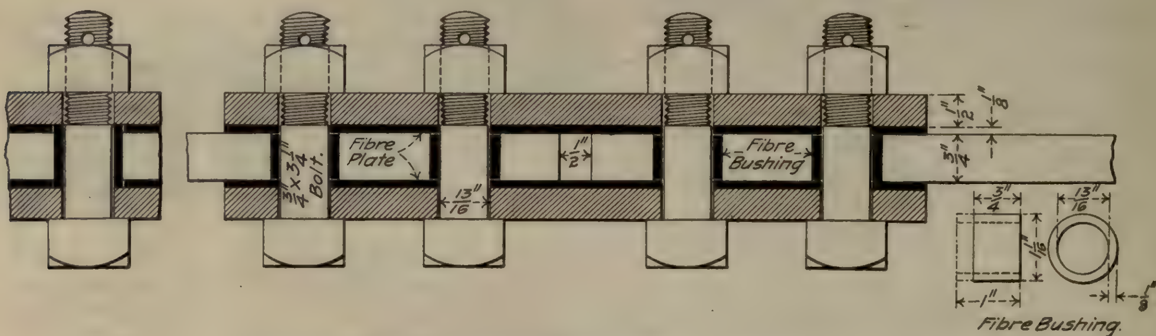
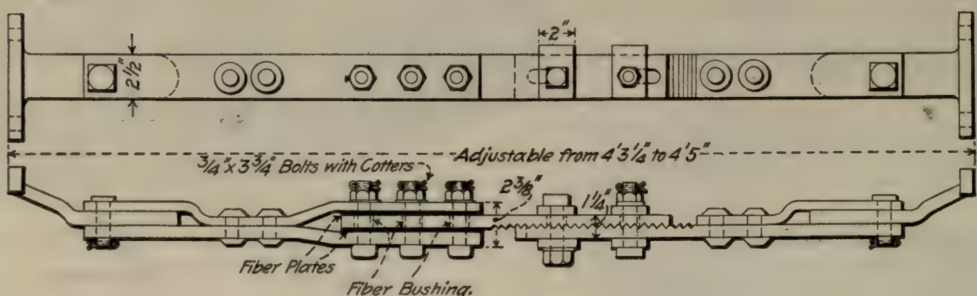


Fig. 3683. Method of Insulating Switch Rods and Tie Plates. Southern Pacific-Union Pacific.



Figs. 3684-3686. Insulated Switch Rod Details.



Figs. 3687-3688. Adjustable Insulated Switch Rod. Chicago, Milwaukee & St. Paul.

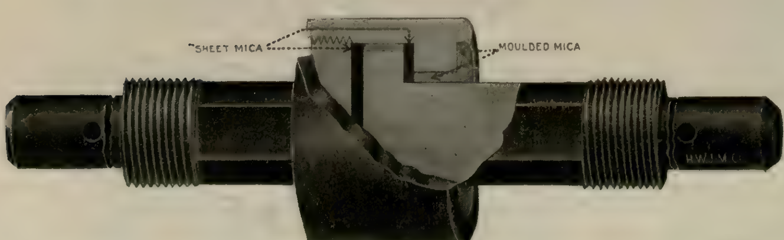
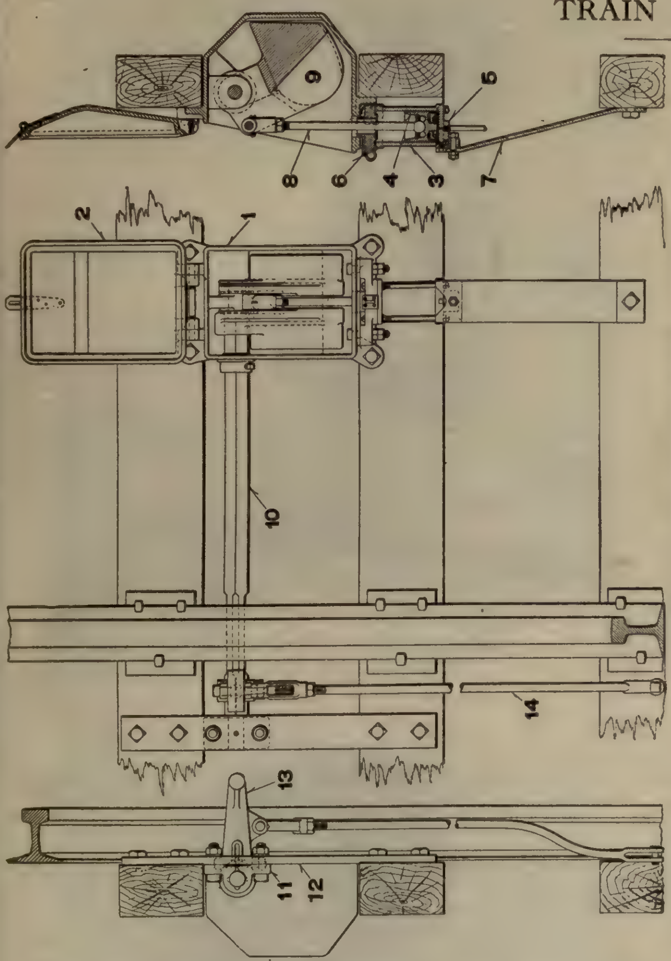


Fig. 3689. Pipe Line Insulation. H. W. Johns-Manville Company.

Fig. 3690. Axle Insulation for Hand Cars. Railroad Supply Company.

TRAIN STOPS



Figs. 3691-3692. Electro-Pneumatic Train Stop. The Union Switch & Signal Company.

Names of Parts, Electro-Pneumatic Train Stop; Figs. 3691-3692.

1 *Counterweight Box*
2 *Counterweight Box Cover*
3 *Cylinder*
4 *Piston*
5 *Front Cylinder Head*
6 *Back Cylinder Head*
7 *Cylinder Guard*
8 *Piston Rod*
9 *Counterweight*
10 *Shaft*
11 *Shaft Bearing*
12 *Bearing Plate*
13 *Stop Arm*
14 *Connecting Rod*

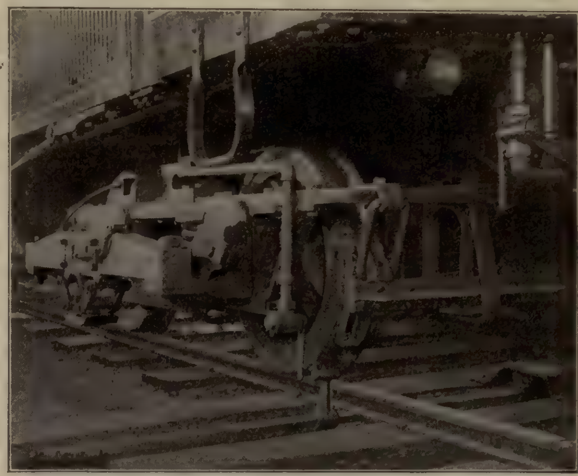


Fig. 3693. Automatic Train Stop. Boston Elevated.

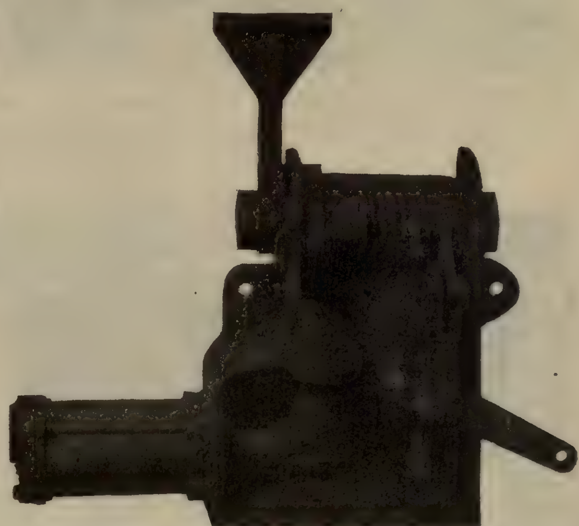


Fig. 3694. Electro-Pneumatic Automatic Train Stop. The Union Switch & Signal Company.

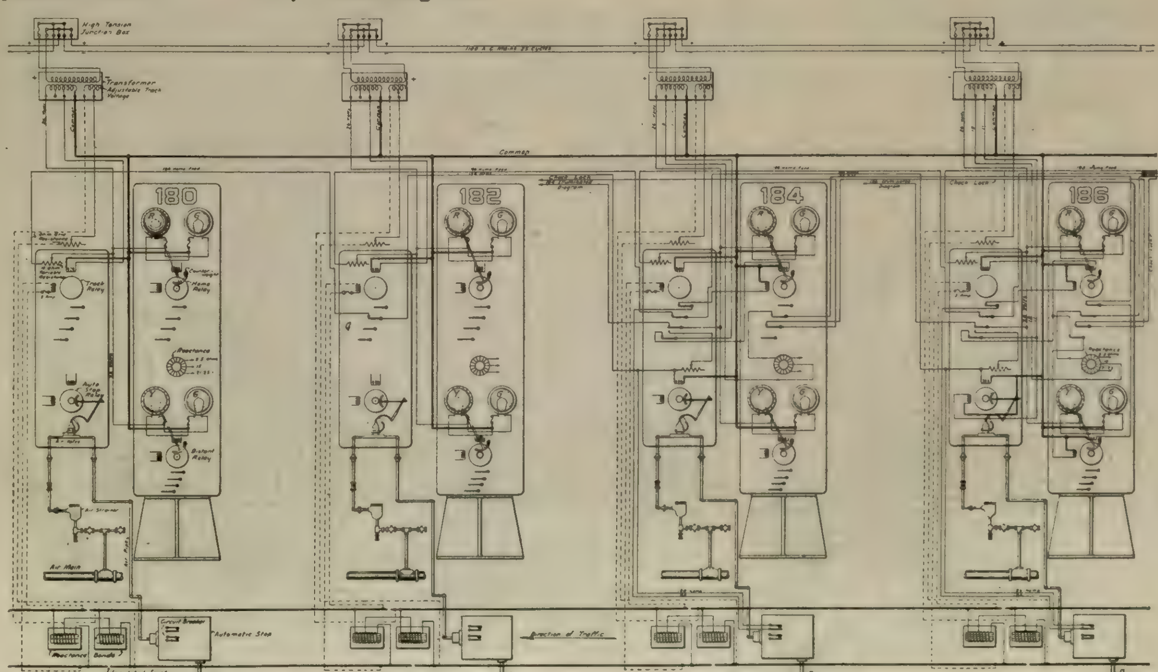


Fig. 3695. Operating Circuits for Automatic Train Stops.

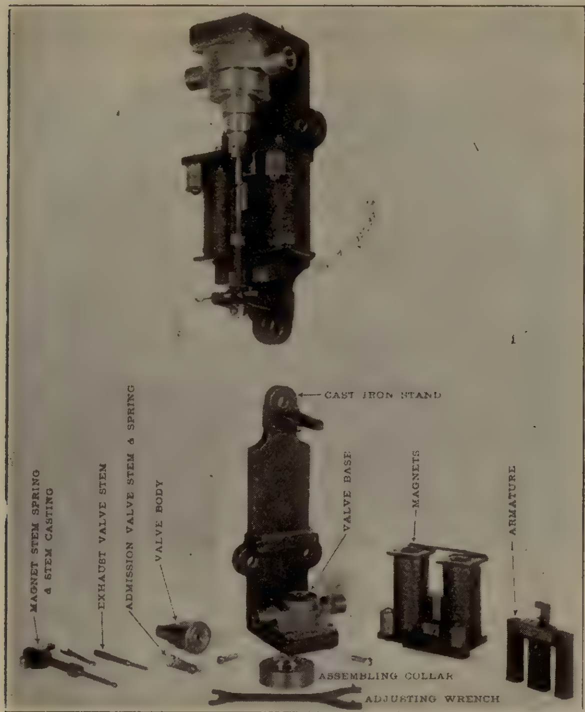


Fig. 3696. Electro-Pneumatic Train Stop. Kinsman Block System Company.

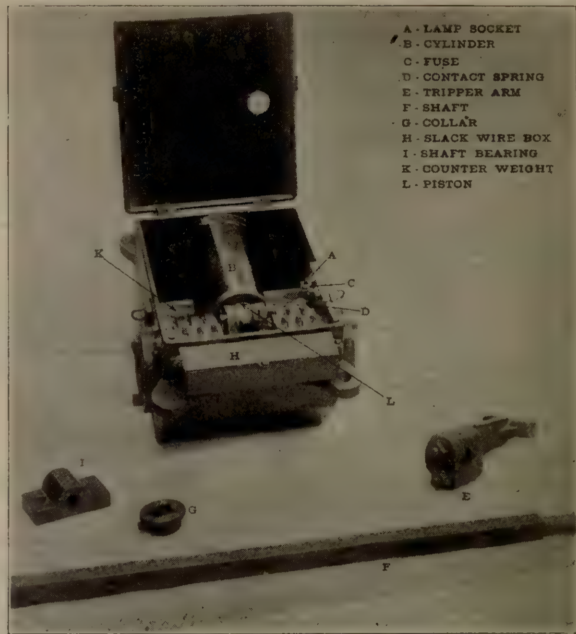


Fig. 3697. Kinsman Electro-Pneumatic Stop With 6 Point Circuit Breaker.

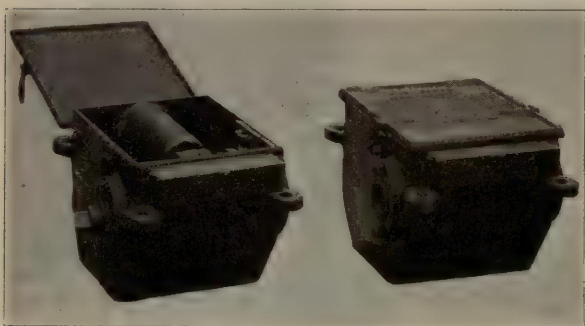


Fig. 3698. Automatic Stop. Kinsman Block System Company.

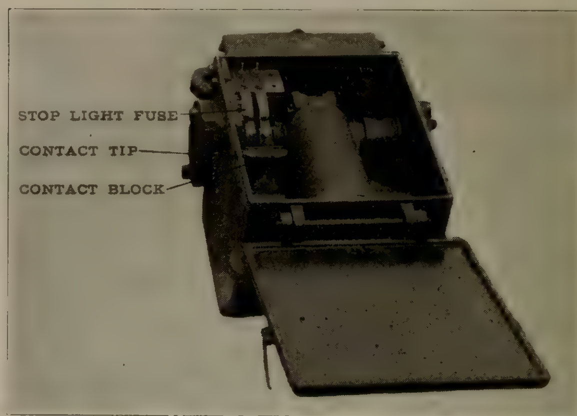


Fig. 3699. Kinsman Stop with 2 Point Circuit Breaker for Use with G. R. S. Apparatus.

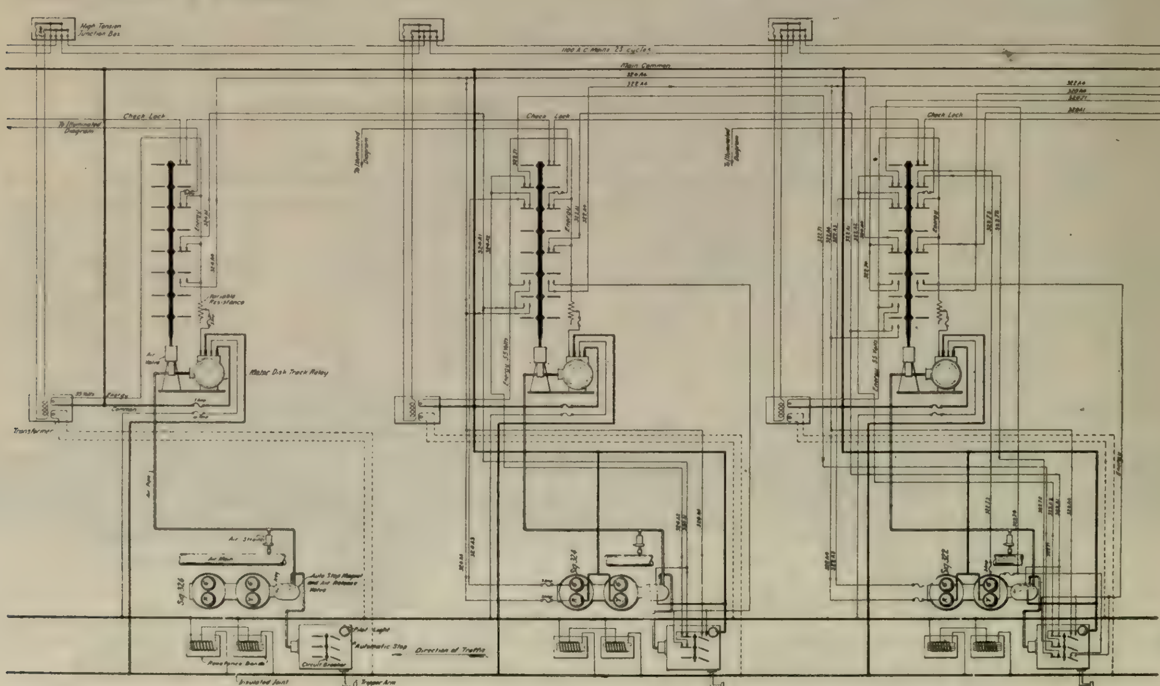
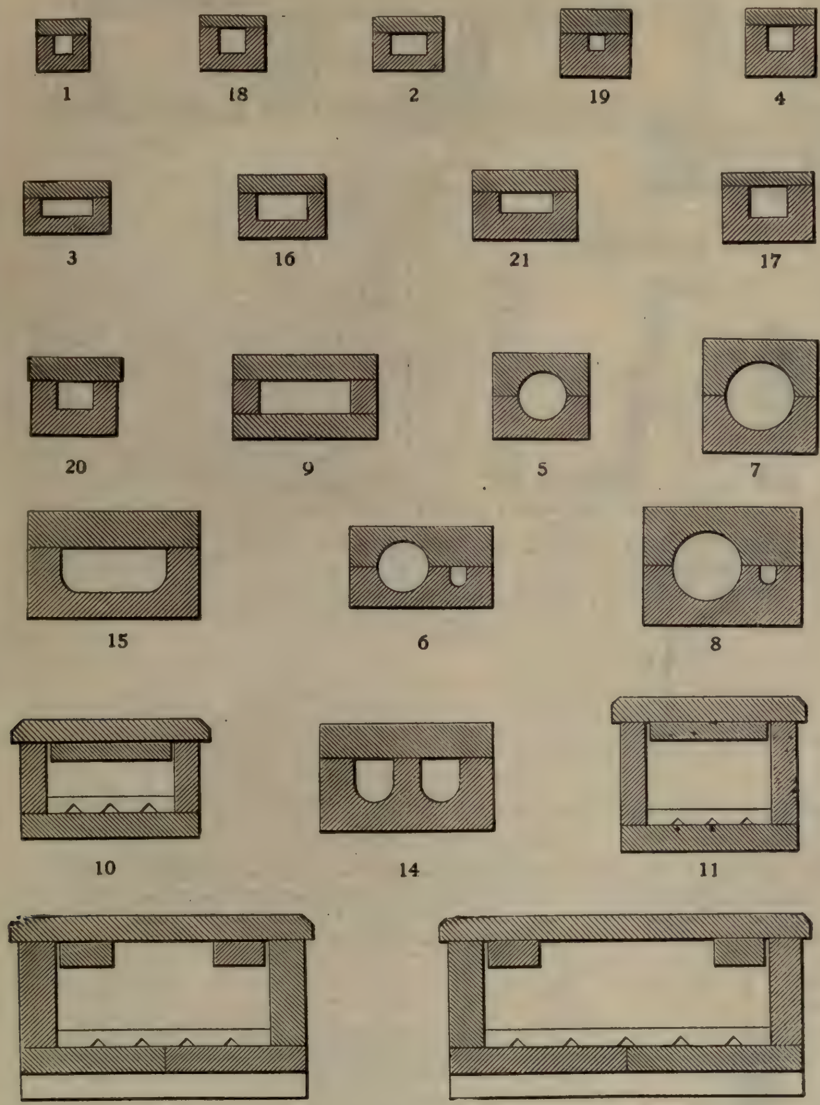


Fig. 3700. Circuit for Automatic Stop.

TRUNKING AND CONDUIT

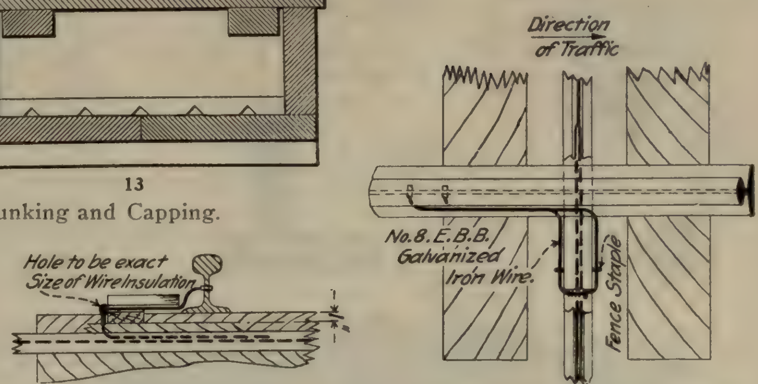
TRUNKING



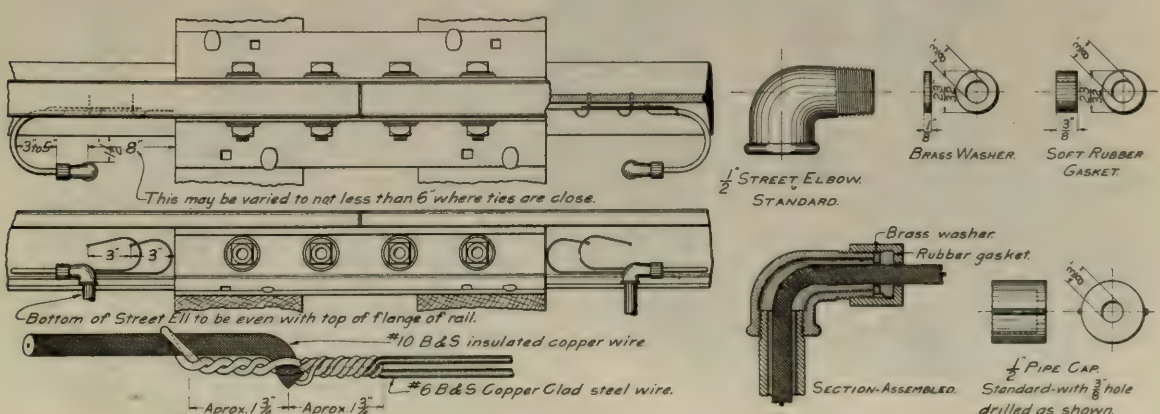
Figs. 3701-3721. Types of Trunking and Capping.

Names of Parts, Trunking; Figs. 3701-3721.

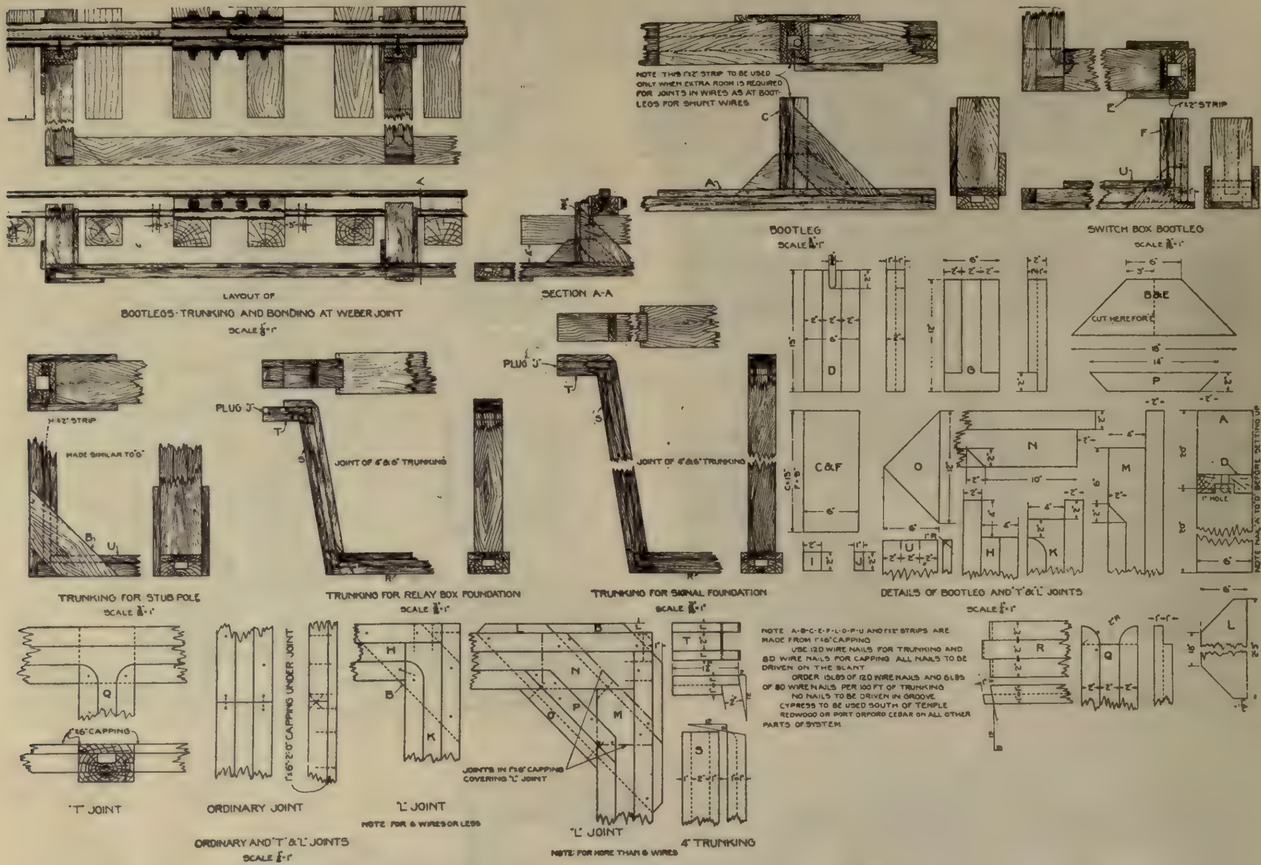
1 *Grooved Trunking with 1" x 1" Opening*
2 *Grooved Trunking with 1" x 2" Opening*
3 *Grooved Trunking with 1" x 3" Opening*
4 *Grooved Trunking with 1½" x 1½" Opening*
5 *Grooved Trunking with 2" Opening*
6 *Grooved Trunking with 2⅞" and 1" Opening*
7 *Grooved Trunking with 4" Opening*
8 *Grooved Trunking with 4" and 1" Opening*
9 *Boxed Trunking with 2" x 5" Opening*
10 *Boxed Trunking with 2" x 7" Opening*
11 *Boxed Trunking with 4" x 7" Opening*
12 *Boxed Trunking with 5" x 12" Opening*
13 *Boxed Trunking with 5" x 16" Opening*
14 *Grooved Trunking with 2¼" and 2½" Opening*
15 *Grooved Trunking with 2½" x 6" Opening*
16 *Grooved Trunking with 2" x 3" Opening*
17 *Grooved Trunking with 1¾" x 2⅛" Opening*
18 *Grooved Trunking with 1⅜" x 1⅜" Opening*
19 *Grooved Trunking with 1" x 1" Opening*
20 *Grooved Trunking with 1½" x 2" Opening*
21 *Grooved Trunking with 1" x 3" Opening*



Figs. 3722-3723. Standard Bootleg and Wire Connections to Rail. New York Central & Hudson River.

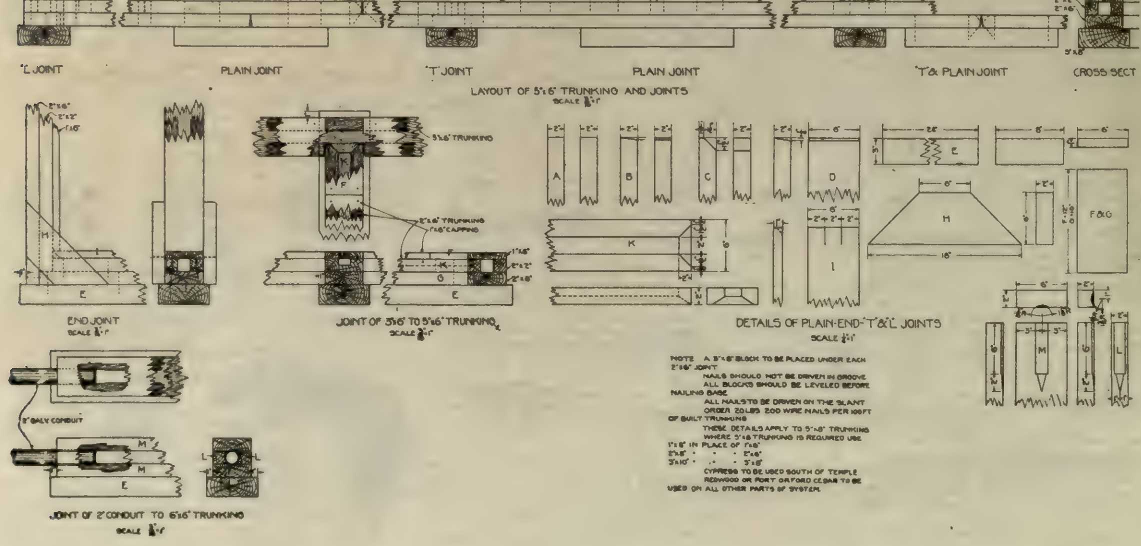


Figs. 3724-3731. Standard Bootleg, and Details of Wire Joints and Connections. Oregon Short Line.

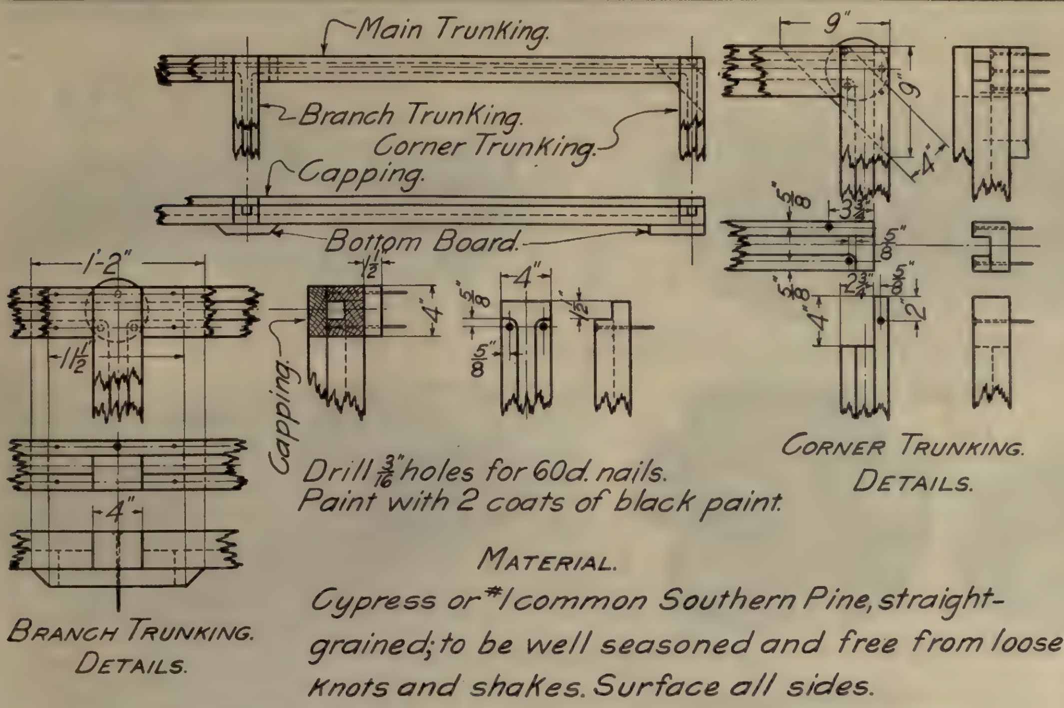


Figs. 3732-3772. Standard Bootleg and Trunking Connections. Atchison, Topeka & Santa Fe.

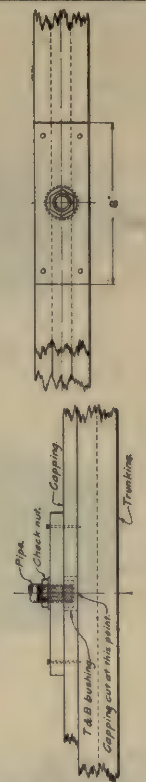
Figs. 3732-3772 show the Atchison, Topeka & Santa Fe standard construction details for grooved trunking; and Figs. 3773-3796 show the standard construction details of the same road for built trunking. The material used for trunking on this road is cypress south of Temple, Texas, and redwood, or Port Orford cedar on all other parts of the system. Figs. 3732-3772 also show the details for standard bootleg to rail connections and for a switch box bootleg.



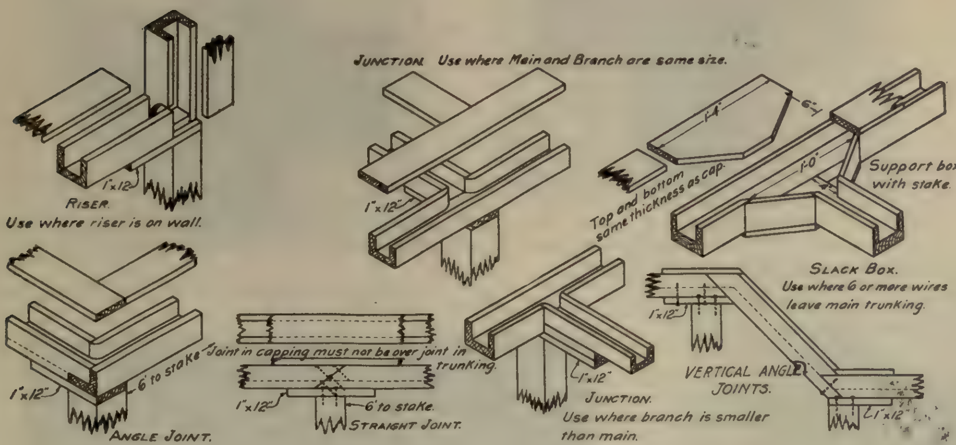
Figs. 3773-3796. Standard Trunking Connections. Atchison, Topeka & Santa Fe.



Figs. 3797-3807. Trunking Branch and Corner Connections, Southern Railway.



Figs. 3808-3809. Pipe Conduit Connections to Wood Trunking. New York Central.



Figs. 3810-3816. Trunking Connections. Southern Railway.

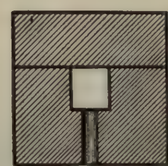


Fig. 3817. Trunking Hole for Drip.

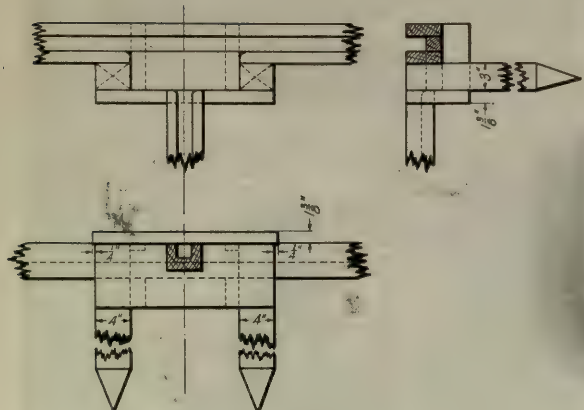


Fig. 3818-3820. Junction Box in Line of Trunking. New York Central.

Fig. 3821. Reinforced Concrete Junction Box. C. F. Massey Company.

CONDUIT

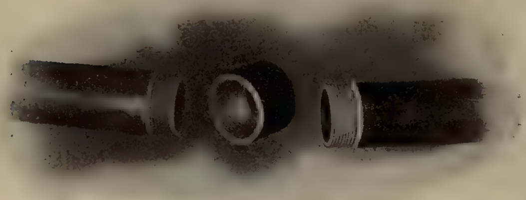


Fig. 3822. Screw Joint Fibre Conduit.

Fig. 3823. Sleeve Joint.

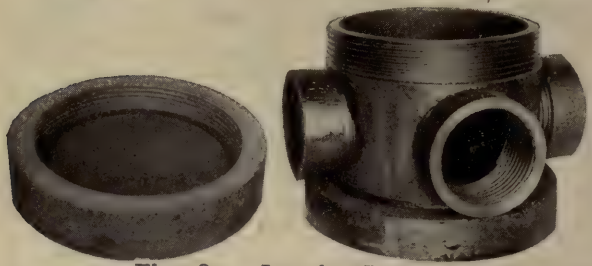


Fig. 3824. Junction Box.

Fig. 3825. Reducer.

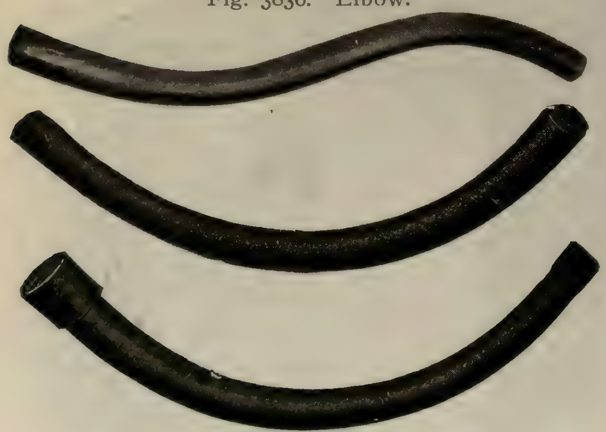
Fig. 3826. Cap.

Fig. 3827. Sleeve.

Fig. 3828. Tee.

Fig. 3829. Cross.

Fig. 3830. Elbow.



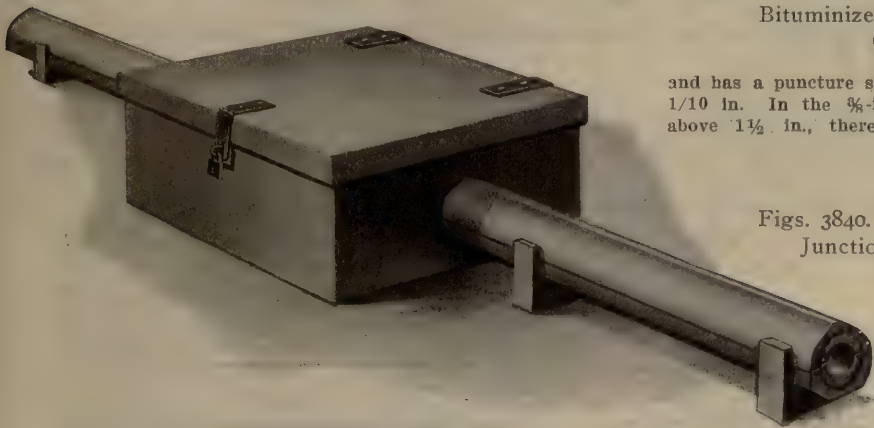
Figs. 3831-3833. Standard Bends.

Figs. 3822-3833. Standard Fittings and Connections Orangeburg Fibre Conduit. Fibre Conduit Company.

Fig. 3834. Installation of Orangeburg Fibre Conduit.

ORANGEBURG FIBRE CONDUIT.

In the process of manufacturing Orangeburg Fibre Conduit, wet wood pulp or fibre is wrapped in a minutely thin film upon a forming mandrel, under pressure, until the desired thickness of wall is obtained. The individual fibres become felted and form a solid, homogeneous wall. Taken off the mandrel, the wet pulp structure is subjected to a drying process, after which it is placed in a vat of liquid compound. This compound is a preservative and is also insulating and waterproofing. It thoroughly permeates the entire structure, so that after treatment the wall of the conduit, when cut, presents a strong resemblance to hard rubber. The ends are cut in a lathe to make a socket joint, sleeve joint or screw joint thread, as may be desired.



Figs. 3840. Reinforced Concrete Trunking and Junction Box. C. F. Massey Company.

The same materials and general process are employed in producing bends of various degrees and radii, "S" bends, tees, elbows, crosses, couplings and junction boxes, with the varying number of outlets.

Orangeburg Fibre Conduit is waterproof and is not affected by acids, alkalies or gases. It contains nothing that will injure the insulation of wires, and prevents electrolysis. Its insulating qualities enable it to withstand a puncture test of 25,000 volts a. c. It is not inflammable. If a steady flame is applied to it, it will burn, but the flame will not spread and when the heat is taken away it immediately stops burning.

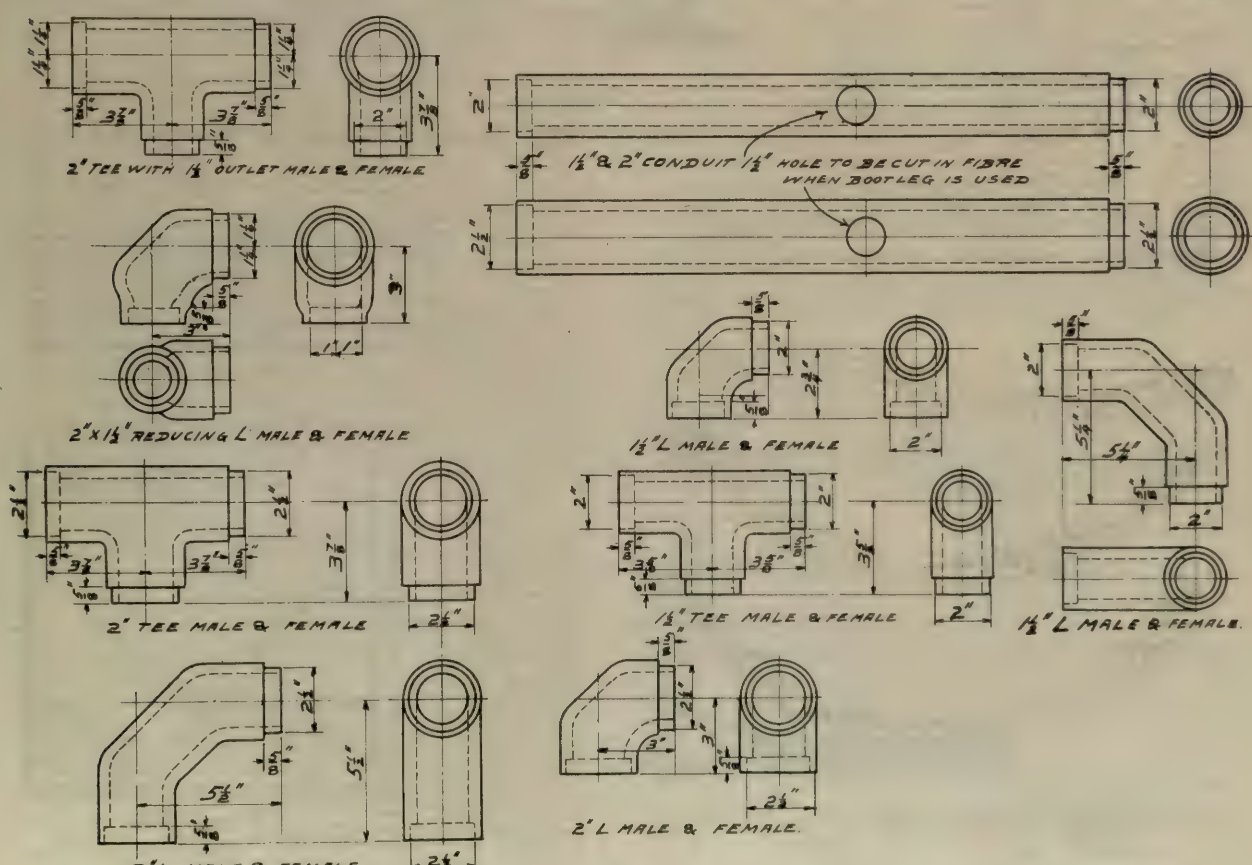
AMERICAN BITUMINIZED CONDUIT.

American bituminized fibre conduit is made up of a series of laminations of thoroughly saturated fibre alternating with layers of an insulating compound that is impervious to moisture

Figs. 3835-3839. Standard Sections and Fittings of Bituminized Fibre Conduit. American Conduit Company.

and has a puncture strength of 40,000 volts for a thickness of 1/10 in. In the ⅝-in. wall, which is standard for all sizes above 1½ in., there are 26 of these laminations securely cemented together. A puncture test of 50,000 volts is guaranteed. The absorption of moisture by this conduit after it is laid is eliminated by passing the laminations through the saturating compound one at a time, thus insuring thorough penetration.

The conduit is made in sizes from one in. to eight in. internal diameter. The one in. and 1½ in. sizes are made in five ft. lengths and have a joint ½ in. long. The larger sizes are made in seven ft. lengths with a ⅝ in. joint. Fittings of every description for signal work are made by the same process as that employed in the manufacture of the conduit.



Figs. 3841-3850. Standard Sections and Fittings Bituminized Fibre Conduit. American Conduit Company.

BOOTLEGS AND CONNECTIONS

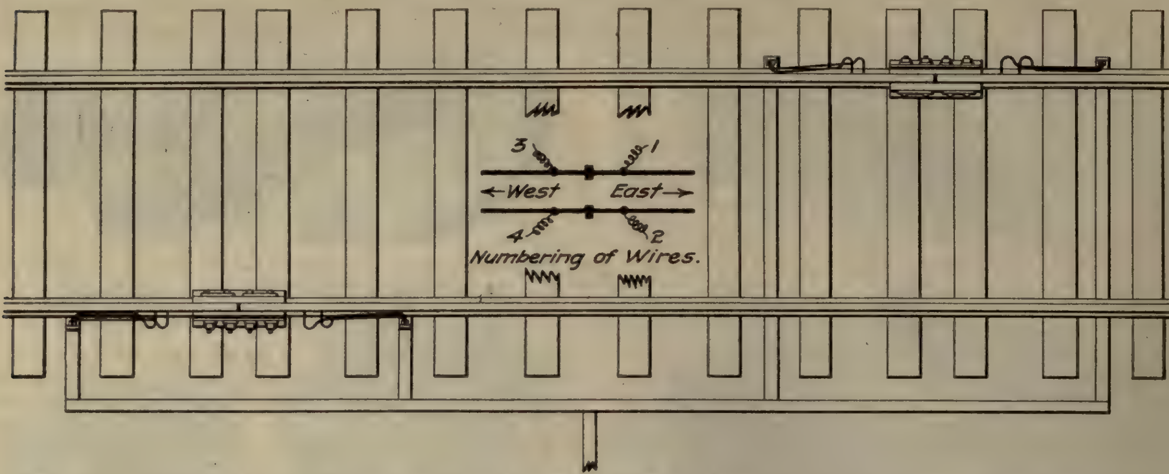
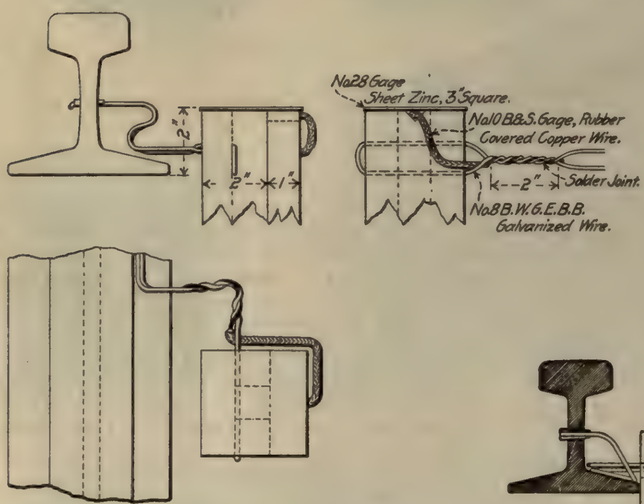
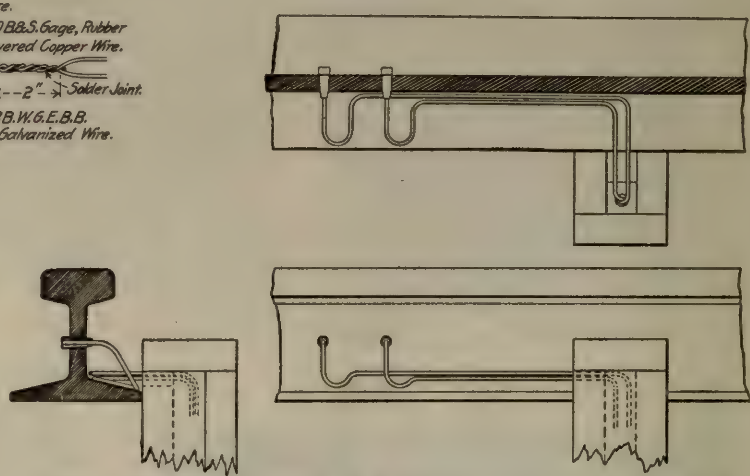


Fig. 3851. Standard Track Wiring and Trunking Run at Signal Location or Cut Section. Southern Pacific-Union Pacific.



Figs. 3852-3854. Bootleg and Wire Connection to Rail. Union Pacific.



Figs. 3855-3857. Details of Bootleg and Connection to Rail

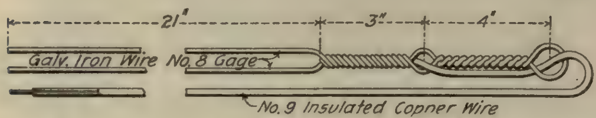
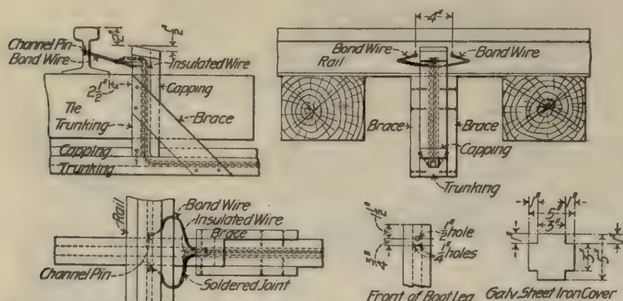
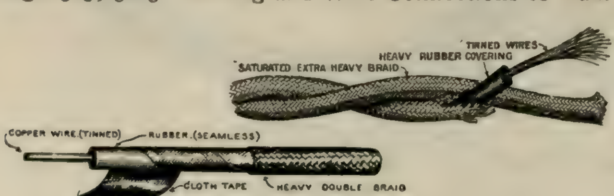


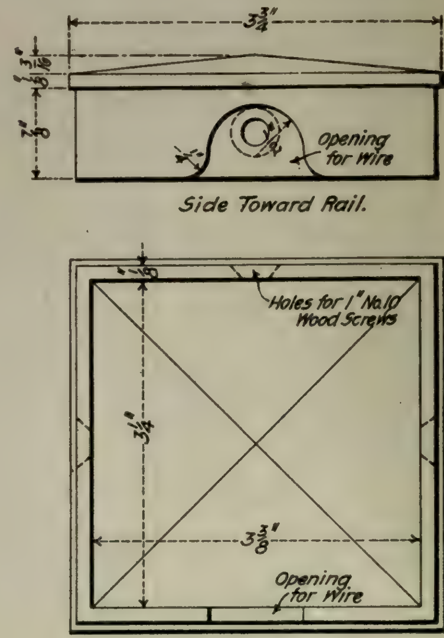
Fig. 3858. Detail of Wire Bootleg. Michigan Central.



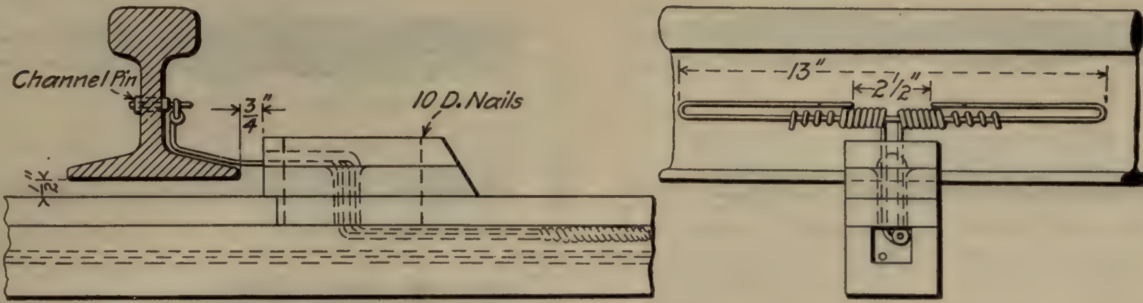
Figs. 3859-3863. Bootleg and Wire Connections to Rail.



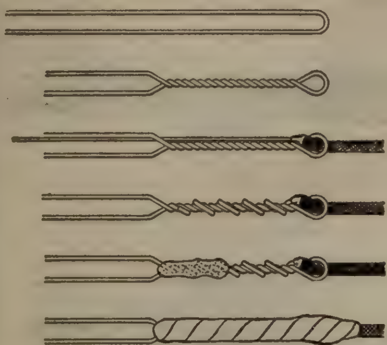
Figs. 3864-3865. Wire Insulation.



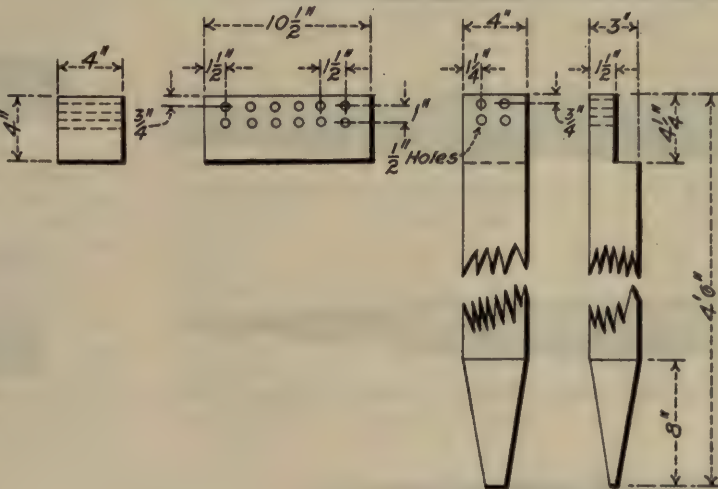
Figs. 3866-3867. Malleable Iron Bootleg Cap. Long Island Railroad. T. George Stiles Company.



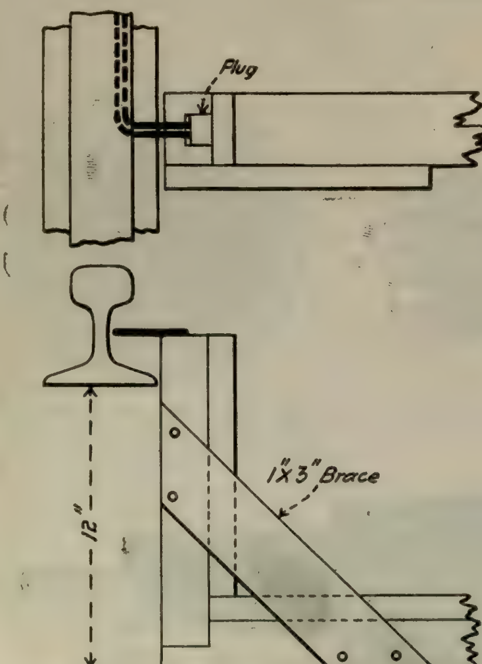
Figs. 3868-3869. Standard Bootleg and Wire Connections to Rail. Illinois Central.



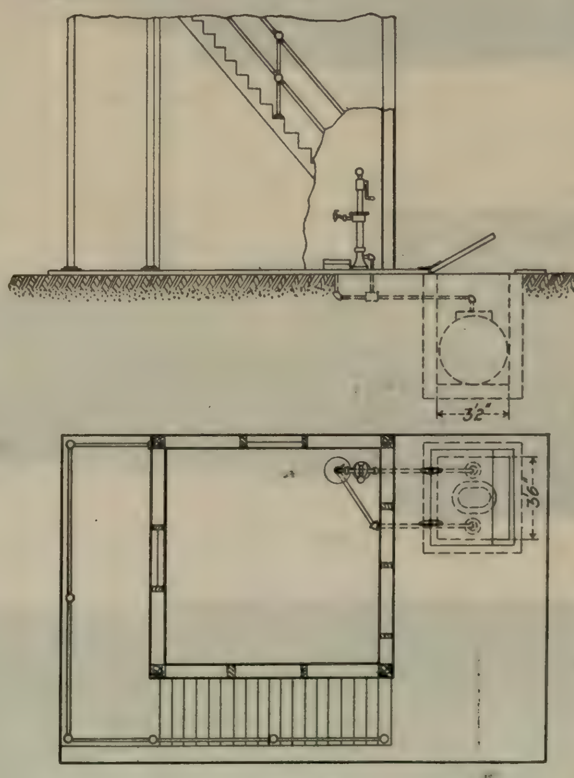
Figs. 3870-3875. Successive Stages in Connecting Iron Bond Wire to Copper Lead to Make Wire Bootleg. The Union Switch & Signal Company.



Figs. 3876-3879. Wooden Trunking Stake and Details. Chicago, Milwaukee & St. Paul.



Figs. 3880-3881. Standard Bootleg and Wire Connection to Rail. Southern Pacific.



Figs. 3882-3883. Location of Oil Tank and Pump at Interlocking Tower. New York Central & Hudson River.

Fig. 3884. Insulated Twisted Wire.

Fig. 3885. Insulated Flat Pair.

Fig. 3886. Solid Copper Conductor; Insulated Plain.

Fig. 3887. Same as Fig. 3886, with Braid.

Fig. 3888. Same as Fig. 3886, Taped.

Fig. 3889. Same as Fig. 3888, with Braid.

Fig. 3890. Solid Copper Conductor; Insulated and Lead Covered.

Fig. 3891. Solid Copper Conductor; Insulated with Two Tapes and One Braid.

Fig. 3892. Solid Copper Conductor; Insulated and Lead Covered.

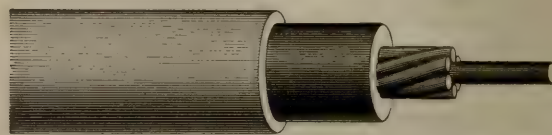


Fig. 3893. Stranded Copper Conductor; Insulated and Lead Covered.

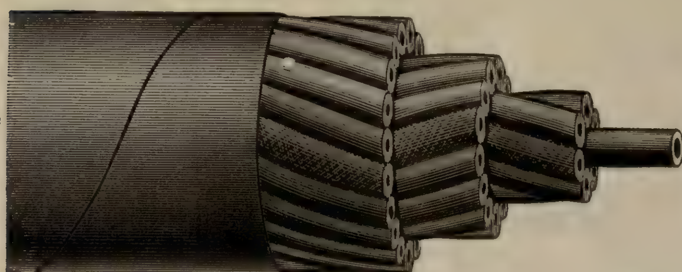


Fig. 3894. 37-Conductor Aerial Cable.

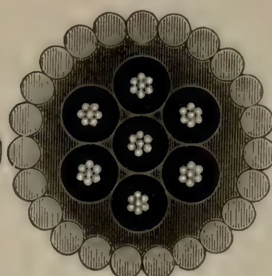


Fig. 3895. Seven-Conductor Submarine Cable.

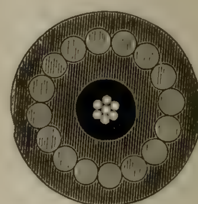


Fig. 3896. Single Conductor Submarine Cable.

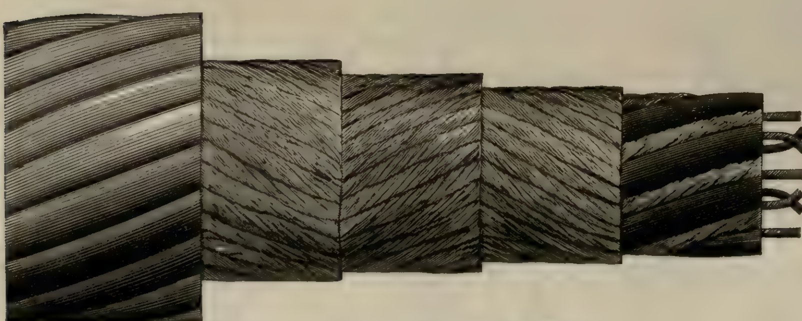


Fig. 3897. Armored Submarine Cable.

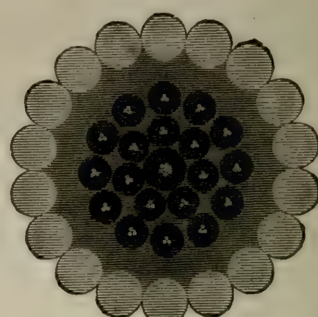


Fig. 3898. 20-Conductor Submarine Cable, with Common Return.

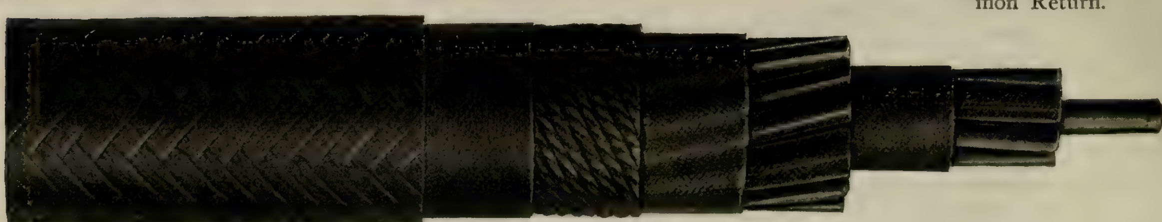


Fig. 3899. 19-Conductor Aerial Cable.

KERITE.

Kerite is an insulation for electrical conductors. It is a homogeneous combination of crude kerite and upriver fine para rubber. Unlike rubber mineral insulations its life is not limited to that of the rubber; the crude kerite (which is itself an active insulating compound) serving to prevent drying out of the insulation, diminution of insulating qualities and the injurious effects of deteriorating agencies. Kerite was originated about 1850. It is extensively used for railway signal work and other purposes where durability and permanency of insulating properties are required.

OKONITE.

Okonite is a rubber compound for insulating electrical conductors. It is composed of pure "Fine Para" rubber and dry mineral matter, these materials being combined by an exclusive formula in the proportion of 30 per cent rubber to 70 per cent mineral matter. The method of manufacture is designed to retain all the inherent properties of the rubber and to increase its durability for insulating purposes to the greatest possible extent. Okonite insulation is distinguished by a single ridge running the length of the wire to which it is applied.

INSULATION RESISTANCES.

The following revised table of insulation resistances in megohms per mile at sixty (60) degrees Fahrenheit for the various thicknesses of insulation and the various sizes of wire has been recommended for adoption by the Railway Signal Association:

B. & S. G.	3/64	2/32	5/64	3/32	7/64	4/32	5/32	6/32	7/32	8/32
0	....	....	900	1000	1200	1300	1500	1800	2000	2200
1	....	....	1000	1200	1400	1500	1800	1900	2200	2300
2	....	1000	1100	1400	1500	1600	1900	2200	2300	2600
3	....	1100	1200	1500	1600	1800	2000	2300	2600	2700
4	....	1200	1400	1600	1800	1900	2200	2400	2700	2800
5	....	1300	1500	1700	1900	2000	2300	2600	2800	3100
6	....	1400	1600	1800	2000	2200	2600	2800	3100	3400
8	1400	1600	1900	2200	2300	2600	2800	3200	3500	3800
9	1500	1800	2000	2300	2600	2700	3100	3400	3600	3900
10	1600	1900	2200	2400	2700	3000	3200	3600	3900	4200
12	1800	2200	2500	2800	3100	3200	3600	4000	4300	4600
14	2200	2600	2800	3200	3500	3600	4200	4400	4800	5100

In the manufacture of cables where the conductors are composed of a number of wires, it is necessary that the wires or strands be of a proper size to give a perfect lay for each conductor, as wires of exact B. & S. gauge size will not always give a perfect lay, and there has been developed in the trade various sizes of strands of wires which are standard in the manufacture of stranded and flexible conductors. These special standard sizes of strands are not given or referred to in catalogues intended for a purchaser's use, but should a cable be ordered with conductors of a size requiring strands of other sizes than the manufacturer's standard, a higher price is charged and longer time required in the making of the cable, owing to the special strands that have to be procured. It is, therefore, advisable that, when ordering cables with flexible conductors, these should conform to the requirements of the following tables, which differ only in the sizes of the strands used and, therefore, in the flexibility of the conductors.

REVISED SPECIFICATION FOR DOUBLE BRAIDED, WEATHERPROOF, HARD DRAWN COPPER LINE WIRE.

General Description.

1. The intention of this specification is to provide for the furnishing of hard drawn copper line wire which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splints and all imperfections. Each coil must contain no weld, joint or splice.

Properties.

3. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. & S. Gauge.	Diameter in Mils.	Breaking Strength, Pounds.	Per Cent Elongation in 10 Inches.	Conductivity Per Cent of Pure Copper.
6	162	1210	1.12	97
7	144	970	1.08	97
8	128	779	1.06	97
9	114	620	1.04	97
10	102	502	1.02	97
12	81	319	1.00	97

Covering.

4. The conductor shall be covered with two (2) closely woven braids of cotton, each of which shall not be less than one-thirty-second (1-32) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

5. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is allowable with the elastic limit required. The wire must remain in the compound and must be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

6. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit, and shall

STRANDED CONDUCTORS.

Approximate Size, B. & S. Gauge.	Number of Strands.	Actual Circular Mils.
2000000	127	2000250
1500000	91	1502592
1000000	91	1003275
900000	91	900900
800000	91	804076
700000	61	698389
600000	61	597861
500000	37	506493
400000	37	400192
350000	37	351722
300000	37	299700
250000	37	248788
0000	19	211470
000	19	167884
00	19	132468
0	19	105450
1	19	84018
2	19	66139
3	7	52274
4	7	41503
5	7	33327
6	7	26047
8	7	16464
9	7	12943
10	7	10374
12	7	6300
14	7	4375
16	7	2527
18-7 No. 26	7	1778
20-7 No. 28	7	1113
21-7 No. 29	7	889
22-7 No. 30	7	700

FLEXIBLE CONDUCTORS.

Approximate Size, B. & S. Gauge.	Number of Strands.	Actual Circular Mils.
0000	37	210900
000	37	168572
00	37	133200
0	37	105894
1	37	83472
2	37	66822
3	19	52364
4	19	41971
5	19	33516
6	19	26011
8	19	17011
9	19	12844
10	19	10051
12	19	6498
14	19	3990
16	19	2508
18-7 No. 26	19	1501

not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero Fahrenheit.

7. The qualities of the compound and the method of application shall be such as not to injure the braided covering or the wire.

8. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean white glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for

half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers or in case the compound is absorbed by the paper as indicated by a greasy or oily spot.

9. The finished wire shall be immersed in a freezing mixture, which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and Tests.

10. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire, at any stage of the manufacture.

11. The manufacturer must provide at the mill all apparatus and labor for making the required tests under the supervision of the purchaser.

12. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

13. If upon arrival at destination the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who must pay all freight charges.

Packing for Shipment.

14. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive..................One-fourth mile.
6 to 8, inclusive..................One-third mile.
9 to 12, inclusive..................One-half mile.

15. The diameter of the eye of the coil shall be not less than twenty (20) inches, nor more than twenty-two (22) inches.

16. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

17. Each coil shall have the weight, length and size of wire, the name of maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

REVISED SPECIFICATION FOR RUBBER INSULATED SIGNAL WIRE FOR CURRENT OF 660 VOLTS OR LESS.

Conductors.

1. Conductors must be of soft drawn, annealed copper wire having a conductivity of not less than ninety-eight (98) per cent of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous, without weld, splice or joint throughout its length, must be uniform in cross section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

Rubber Insulation.

2. The rubber insulation shall be made exclusively from pure Upriver, fine, dry Para rubber, of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

3. The insulation must be homogeneous in character, tough, elastic, adhering strongly to and be placed concentrically around the wire.

Braiding.

4. The rubber insulation must be protected with one layer of closely woven cotton braiding at least one-thirty-second (1-32) of an inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

5. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the wire furnished and the acceptance of the same shall be made by the purchaser.

Tests.

6. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

7. Tests shall be made from samples taken from any part of any coil, and may also be made upon the finished product immediately after being delivered. If the requirements of this specification are not met, the wire will be rejected and the manufacturer shall pay freight charges for return of such material.

8. At the option of the purchaser, the wire, after being tested, shall not be shipped from the factory until an analysis of a sample has been made by a chemist chosen by the purchaser, and the results of such analysis as interpreted by the purchaser shall be sufficient ground for rejection should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

9. Each solid conductor must stand an elongation of twenty-five (25) per cent of its length in ten (10) inches before breaking, and must be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity Test of Copper.

10. The conductivity of the copper shall be determined by measuring the resistance of a length of the wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

11. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times, and if the sample does not become clearly blackened after the fourth immersion, the tinning shall be regarded as satisfactory.

12. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Tests of Braiding.

13. A six (6) inch sample of wire with carefully paraffined ends shall be submerged in fresh water of a temperature of 70 degrees Fahrenheit for a period of twenty-four (24) hours. The difference in weight of the sample before and after submersion must not be more than ten (10) per cent of the weight of the sample before submersion less the weight of the copper and vulcanized rubber.

Physical Tests of Rubber Insulation.

14. A sample of the vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The sample shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths (2 7-16) inches apart. The sample shall then be stretched until the marks are nine (9) inches apart before breaking.

15. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand (1,000) pounds per square inch. The sample, for five (5) minutes before and as near as practicable during the test, shall be maintained at a temperature of seventy (70) degrees Fahrenheit.

16. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

17. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent of pure Upriver, fine, dry Para rubber of best quality; not more than four (4) per cent of waxy hydrocarbons consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent of free sulphur; not more than 2.5 per cent total sulphur; freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Size B. & S. Gauge.	Area in Circular Mils.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
0	105,592	⅛" wall	900	10,000
1	83,694	⅛" "	1,100	10,000
2	66,373	⅛" "	1,200	10,000
4	41,742	3-32" "	1,100	9,000
6	26,250	3-32" "	1,300	9,000
8	16,509	3-32" "	1,600	9,000
9	13,090	5-64" "	1,500	7,000
10	10,380	5-64" "	1,600	7,000
12	6,530	5-64" "	1,900	7,000
14	4,107	5-64" "	2,100	7,000
16	2,583	1-16" "	2,100	4,000
18	1,624	1-16" "	2,400	4,000

Electrical Tests of Rubber Insulation.

18. The circular mils cross section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire shall conform to the requirements shown on the opposite page.

19. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water and, while still immersed, results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination, and before the application of braid or other covering with a well-insulated battery and galvanometer, with not less than one hundred (100) volts and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

Coils

20. The wire shall be furnished in coils of the length named for the following sizes of wire:

B. & S. Gauge.	Length in Feet.
No. 14	2,000
No. 12	1,500
No. 10	1,500
No. 8	1,500
No. 6	1,000

21. Twenty (20) per cent of the coils will be accepted if five hundred (500) feet long or over, or of any length where a coil submitted for inspection and testing has been cut to secure a sample for testing.

22. The inside diameter of a coil shall, unless otherwise specified, be not less than twenty (20) or more than twenty-two (22) inches.

Packing for Shipment.

23. The wire shall be shipped in reels or coils as directed by the purchaser.

24. If shipped on reels they shall be amply strong and the wire shall be protected by lagging to prevent injury in transportation. A tag must be placed inside of the lagging and a stencil on the outside of each reel giving the weight, the length of each piece of wire, the size of the wire, the name of the manufacturer and purchaser's order or inspection number plainly marked.

25. If shipped in coils, each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

26. Each coil shall have the weight, length and size of wire, the name of maker and purchaser's order or inspection number plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

SPECIFICATION FOR AERIAL BRAIDED CABLES FOR CURRENT OF 660 VOLTS OR LESS.

General:

1. The cable brought under this specification will be used for.......................................current at...... ....volts, and shall be...... ....feet in length.

2. All workmanship and material shall be first-class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical engineering practice.

Form of Cable.

3. The cable shall consist of........................... conductors insulated with rubber and stranded into cable with jute laterals to make round. The whole shall be taped and the core thus formed shall be wrapped with jute covered with a closely-woven braid, as herein specified.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gauge Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

5. Conductors must be of soft-drawn, annealed copper wire, having a conductivity of not less than ninety-eight (98) per cent of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous, without weld, splice or joint throughout its length, must be uniform in cross section, free from flaws, scales and other imperfections, and provided with a heavy uniform coating of tin.

Rubber Insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry Para rubber of best quality, which has not previously been used in a rubber compound, solid, waxy, hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients, the rubber shall be thoroughly washed and dried.

7. The insulation must be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Taping, Filling and Braiding.

8. The core of the cable must be made cylindrical in form and properly laid up with one wire in each layer taped for a tracer. Cables of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core must have a spiral lay, each consecutive layer being spiralled in reverse direction from the preceding one. All interstices between insulated conductors must be thoroughly filled with dry jute to make round, and covered with a layer of rubber insulating tape overlapping for one-third (1-3) its width. The tape shall be of closely-woven cotton, filled with rubber insulating compound and laid to make a smooth surface.

9. A bedding of jute, not less than one-sixteenth (1-16) inch thick and saturated with tar, shall be wrapped over the taped core. A layer of tape, overlapping one-third (1-3) its width, shall be laid on over the jute in reverse order to the winding of the jute, and over this shall be placed one (1) layer of closely-woven cotton braiding at least one-thirty-second (1-32) inch thick, saturated with a black, insulating weather-proof compound that shall be neither injuriously affected by nor have an injurious effect on the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

10. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

11. The manufacturer shall provide, at his factory, apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

12. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before and, if desired, immediately after being delivered. If the requirements of this specification are not met the cable will be rejected.

13. At the option of the purchaser, the wire, after being tested, shall not be made into a cable until an analysis of a sample has been made by a chemist chosen by the purchaser, and the results of such analysis as interpreted by the purchaser shall be sufficient ground for rejection should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

14. Each solid conductor must stand an elongation of twenty-five (25) per cent of its length in ten (10) inches before breaking. It must be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity Test of Copper.

15. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

16. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times, and if the sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

17. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Physical Tests of Rubber Insulation.

18. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths (2 7-16) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

19. The tensile strength of the rubber insulation, as shown by tests made on a carefully prepared sample, shall be not less than one thousand (1,000) pounds per square inch. The sample, for five (5) minutes before and as near as practicable during the test, shall be maintained at a temperature of seventy (70) degrees Fahrenheit.

20. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

21. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent of pure Upriver, fine, dry Para rubber, of best quality; nor more than four (4) per cent of solid, waxy hydrocarbons, consisting of refined paraffin or pure ozokerite; not more than 0.7 per cent of free sulphur; not more than 2.5 per cent total sulphur, freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical Tests of Rubber Insulation.

22. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit and the dielectric strength shall conform to the following requirements:

B. & S. Gauge.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
4	3-32 inch	1100	9000
6	5-64 "	1300	7000
8	5-64 "	1600	7000
9	5-64 "	1500	7000
10	1-16 "	1400	4000
12	1-16 "	1600	4000
14	1-16 "	1900	4000
16	3-64 "	1900	2000

23. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water, and while still immersed results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination and before the application of tape or other covering with a well-insulated battery and galvanometer, with not less than one hundred (100) volts, and readings must be taken after one (1) minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

24. The cable, when made up after assembling and braiding, shall have the test voltage required for separate conductors, applied between conductors for five (5) minutes to each conductor.

25. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable and the resistance found shall be not less than that specified for separate conductors.

Inspection.

26. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin, in order that inspection may be arranged for.

Reels.

27. Each cable shall be placed on a separate reel holding the full length of cable. Both ends of cable must be accessible for testing, but be covered and protected from injury. The flanges of the reel shall be large enough to protect the cable in handling and rolling. The reels will become the property of the purchaser, but must be taken back by the manufacturer upon the request of the purchaser.

Marking.

28. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable, and also stenciled on the outside of the reel.

Notification.

29. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable, on arrival at destination, be found defective and not up to the specification requirements, it will be returned to the manufacturer, who must pay all freight charges.

REVISED SPECIFICATION FOR GALVANIZED E. B. B. IRON BOND WIRES.

General Description.

1. The intention of this specification is to provide for the furnishing of No. 8 B. W. G. galvanized E. B. B. iron wires for bonding rail joints of steam railroads where electric track circuits are to be used.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. The wires shall be cut and straightened to the length specified on order. The ends shall be sheared cut and free from burrs.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. W. Gauge	Diameter in Mils.	Breaking Resistance, Pounds.	Per Cent Elongation in 10 Inches.	Resistance Ohms per Mile at 68 Deg. F.
8	165	975	15	12.05

The wire shall not vary more than three (3) mils from the normal diameter.

Test of Galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clean water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65 degrees F. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (Cu O), which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. The solution must be maintained at a temperature between 62 and 68 degrees Fahrenheit during the test. The samples shall be immersed in the solution to a depth of four (4) inches.

8. The samples shall be immersed in the solution for one minute, shall then be washed in clean water having a temperature of between 62 and 68 degrees Fahrenheit and be wiped dry with clean cotton waste. This operation shall be performed four (4) times.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire, represented by the samples, shall be rejected, but copper deposited on zinc or within one (1) inch of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same bundle, but unless the two (2) check tests are satisfactory, the wire shall be rejected.

Inspection and Tests.

11. The purchaser is to have the right to make such inspection and tests as he may desire of the wire at any stage of the manufacture.

12. The manufacturer must provide, at the mill, all apparatus and labor for making the required tests under the supervision of the purchaser.

13. Tests shall be made at the mill, on the wire before it is cut into lengths, or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination.

14. If, upon arrival at destination, the wires do not meet the requirements of this specification, they will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

15. The wire shall be put in bundles of one hundred (100) or three hundred (300), as ordered, well burlapped at ends and securely fastened in not less than three (3) places.

Tagging.

16. A tag shall be securely fastened to each bundle, having plainly and indelibly marked thereon the number of and length of the wires, the purchaser's order and inspection number and the proper shipping address.

REVISED SPECIFICATION FOR DOUBLE-BRAIDED, WEATHERPROOF, GALVANIZED B. B. IRON LINE WIRE.

General Description.

1. The intention of this specification is to provide for the furnishing of galvanized B. B. iron line wire, which is covered with a double thickness of weather-proof braiding.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no weld, joint or splice.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. W. Gauge	Diameter in Mils.	Breaking Strength, Pounds.	Per Cent Elongation in 10 Inches.	Resistance Ohms per Mile at 68 Deg. F.
6	203	1,652	15	9.49
8	165	1,092	15	14.36
10	134	722	12	21.71
12	109	476	12	32.94

Test of Galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clean water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65 degrees Fahrenheit. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (Cu O), which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. This solution must be maintained at a temperature between 62 and 68 degrees Fahrenheit during the test. The samples shall be immersed in the solution to a depth of four (4) inches.

8. The samples shall be immersed in the solution for one (1) minute, shall then be washed in clean water having a temperature of between 62 and 68 degrees Fahrenheit, and be wiped dry with cotton waste. This operation shall be performed four (4) times.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire, represented by the samples, shall be rejected, but copper deposited on zinc or within one (1) inch of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same coil, but unless the two (2) check tests are satisfactory the wire shall be rejected.

Covering.

11. The conductor shall be covered with two (2) closely-woven braids of cotton, each of which shall not be less than one-thirty-second (1-32) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

12. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is allowable with the elongation required. The wire must remain in the compound long enough to drive out all moisture in the covering and must be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

13. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero Fahrenheit.

14. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

15. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean white glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers, or in case the compound is absorbed by the paper as indicated by a greasy or oily spot.

16. The finished wire shall be immersed in a freezing mixture which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and Tests.

17. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

18. The manufacturer must provide at the mill all apparatus and labor for making the required tests under the supervision of the purchaser.

19. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

20. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

21. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive, one-fourth mile.
6 to 8, inclusive, one-third mile.
9 to 12, inclusive, one-half mile.

22. The diameter of the eye of the coil shall be not less than twenty (20) inches, nor more than twenty-two (22) inches.

23. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

24. Each coil shall have the weight, length and size of wire, the name of the maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

SPECIFICATION FOR RUBBER-INSULATED, LEAD-COVERED, ARMORED SUBMARINE CABLE FOR 660 OR LOWER VOLTAGE SERVICE.

General.

1. The cable bought under this specification will be used under water for........................current at.......................................volts, and shall be....................................feet in length.

2. All workmanship and material shall be first-class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical engineering practice.

Form of Cable.

3. The cable shall consist of............................conductors insulated with rubber and stranded into cable with jute laterals to make round. The whole to be taped and the

core thus formed shall have lead sheath with jute covering over lead, with armor and a covering of jute over the armor as herein specified.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gauge Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

5. Conductors must be of soft-drawn, annealed copper wire having a conductivity of not less than ninety-eight (98) per cent of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous, without weld, splice or joint throughout its length, must be uniform in cross section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

Rubber Insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry Para rubber, of best quality, which has not previously been used in a rubber compound, solid, waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

7. The insulation must be homogeneous in character, tough, elastic, adhering strongly to and be placed concentrically around the wire.

Taping and Filling.

8. The core of the cable must be made cylindrical in form and properly laid up with one wire in each layer taped for a tracer. Cables of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between insulated conductors must be thoroughly filled with dry jute to make round and covered with a layer of rubber insulating tape overlapping for one-third (1-3) its width.

9. The tape shall be of closely-woven cotton filled with rubber insulating compound and laid to make a smooth surface. The jute is to be well twisted and to be applied spirally.

Sheath.

10. A sheath, one-eighth (⅛) of an inch in thickness, consisting of an alloy of lead and tin, containing not less than ninety-eight (98) per cent pure lead and from one (1) to two (2) per cent tin, shall be applied over the assembled and taped conductors.

Armoring and Braiding.

11. The sheath shall be protected by a layer of asphalt or tarred jute, well twisted and applied spirally and having a thickness of three-thirty-seconds (3-32) of an inch. Over the jute covering shall be placed a covering consisting of No. 4 B. & S. gauge galvanized mild steel wires applied spirally and laid to fit closely, one wire to the next.

12. Over the armoring a layer of closely-woven jute braiding shall be placed, at least one-sixteenth (1-16) inch thick, saturated with a black, insulating weatherproof compound that shall be neither injuriously affected by nor have an injurious effect upon the braid at 200 degrees Fahrenheit.

Acceptance.

13. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

14. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

15. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before and, if desired, immediately after being delivered. If the requirements of this specification are not met the cable will be rejected.

16. At the option of the purchaser, the wire after being tested shall not be made into a cable until an analysis of a sample has been made by a chemist, chosen by the purchaser, and the results of such analysis as interpreted by the purchaser, shall be sufficient ground for rejection should the wire or insulation not conform to the requirements of this specification.

Physical Test of Copper Conductors.

17. Each solid conductor must stand an elongation of twenty-five (25) per cent of its length in ten (10) inches before breaking. It must be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity Test of Copper.

18. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of Tinning.

19. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times, and if the sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

20. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Physical Tests of Rubber Insulation.

21. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths (2 7-16) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

22. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand (1,000) pounds per square inch. The sample, for five (5) minutes before and as near as practicable during the test, shall be maintained at a temperature of seventy (70) degrees Fahrenheit.

23. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical Tests of Rubber Insulation.

24. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent of pure Upriver, fine, dry Para rubber, of best quality; not more than four (4) per cent of solid, waxy hydrocarbons, consisting of refined paraffin or pure ozokerite; not more than 0.7 per cent of free sulphur; not more than 2.5 per cent total sulphur, freedom from all foreign matter and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical Tests of Rubber Insulation.

25. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit and the dielectric strength shall conform to the following requirements:

B. & S. Gauge.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
0	1-8 inch	900	10,000
1	1-8 "	1100	10,000
2	1-8 "	1200	10,000
4	3-32 "	1100	9000
6	3-32 "	1300	9000
8	3-32 "	1600	9000
9	5-64 "	1500	7000
10	5-64 "	1600	7000
12	5-64 "	1900	7000
14	5-64 "	2100	7000
16	1-16 "	2100	4000

26. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water and while still immersed results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination and before the application of tape or other covering with a well-insulated battery and galvanometer, with not less than one

hundred (100) volts, and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

27. The cable when made up after assembling with lead covering and armoring shall have the test voltage applied for five (5) minutes to each conductor, as follows:

28. Between conductors, apply the full voltage test as required for separate wires.

29. Between each conductor and lead sheath apply a test voltage of but 60 per cent of that required for separate wires.

30. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable and the resistance found shall be not less than that specified for separate conductors.

Inspection.

31. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin, in order that inspection may be arranged for.

Reels.

32. Each cable shall be placed on a separate reel holding the full length of cable. Both ends of cable must be accessible for testing, but be covered and protected from injury. The flanges of the reel shall be large enough to protect the cable in handling and rolling. The reels will become the property of the purchaser, but must be taken back by the manufacturer upon the request of the purchaser.

Marking.

33. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable and also stenciled on the outside of the reel.

Notification.

34. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable on arrival at destination be found defective and not up to the specification requirements, it will be returned to the manufacturer, who must pay all freight charges.

SPECIFICATION FOR DOUBLE-BRAIDED, WEATHERPROOF, HARD-DRAWN, COPPER-CLAD, STEEL LINE WIRE.

General Description.

1. The intention of this specification is to provide for the furnishing of copper-clad, steel line wire, which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire shall be composed of a steel core with a copper coat permanently welded thereto. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no weld, joint or splice.

Properties.

3. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. & S. Gauge	Diameter in Mils.	Breaking Strength, Pounds.	Conductivity Per Cent of Pure Copper at 60 Deg. F.
6	162	1700	35
7	144	1450	35
8	128	1150	35
9	114	950	35
10	102	760	35
12	81	490	35

4. The wire when broken by twisting, repeated bending, or when heated to a dull red and quenched in water at 32 degrees Fahrenheit, shall show no separation of the copper from the steel.

5. Should the breaking weight of the coil be less than that specified, tests of two (2) additional samples shall be made from the same coil and the average of the three (3) tests shall determine the acceptance or rejection of the coil.

6. Should the conductivity of a sample of a coil be lower than that specified, pieces may be cut from each end until samples are obtained having the required conductivity.

Covering.

7. The conductor shall be covered with two (2) closely-woven braids of cotton, each of which shall not be less than one-thirty-second (1-32) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

8. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit or such as will soften the wire more than is allowable with the elongation required. The wire must remain in the compound long enough to drive out all moisture in the covering, and must be closely stripped, so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

9. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below Fahrenheit.

10. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

11. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean white glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed, in sufficient amount to form a ridge perceptible to the fingers, or in case the compound is absorbed by the paper as indicated by a greasy or oil spot.

12. The finished wire shall be immersed in a freezing mixture which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in the surface, the wire shall be rejected.

Inspection and Tests.

13. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

14. The manufacturer must provide at the mill all apparatus and labor for making the required tests under the supervision of the purchaser.

15. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

16. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for Shipment.

17. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive, one-fourth mile.

6 to 8, inclusive, one-third mile.

9 to 12, inclusive, one-half mile.

18. The diameter of the eye of the coil shall be not less than twenty (20) inches, nor more than twenty-two (22) inches.

19. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

20. Each coil shall have the weight, length and size of wire, name of maker, the purchaser's order and inspection number, and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

SPECIFICATIONS FOR WOOD TRUNKING.

General.

1. The material required under these specifications is wooden trunking to be used for the protection of rubber insulated wires in railroad signaling.

2. It must be furnished either surfaced four (4) sides or rough sawed, as specified. When furnished surfaced four (4) sides, it must conform to dimensions shown on R. S. A. drawing .... When furnished rough sawed, the outside dimensions as shown on the drawing will be considered a minimum, and a variation of not more than one-fourth (¼) inch will be allowed for maximum; while for the groove, the dimensions as shown on the drawing must be adhered to for the minimum and an increase in size of one-eighth (⅛) inch either way will be allowed as maximum.

3. Trunking shall be graded on finished or better side, but the other side shall not be more than one grade below.

4. Lumber shall be manufactured and shipped uniform and even in lengths, approximately sixteen (16) feet long. No piece shall be less than fourteen (14) feet nor more than eighteen (18) feet long.

5. Knot holes will not be permitted.

6. Shake will not be permitted.

7. Wane shall not extend more than one-half (½) inch across any face, nor more than one-quarter (¼) the length of any piece.

8. Sides of groove may be sawed, but bottom of groove must be knife cut.

9. May have one split not to exceed in length the width of the piece.

Cypress Trunking.

10. May have one-half (½) inch bright sap on either edge.

11. May have one (1) to three (3) small sound knots not more than three-quarters (¾) inch in diameter if well scattered so as not to materially affect the strength of the piece.

White and Norway Pine.

12. White sap will not be considered a defect. A small amount (not more than ten [10] per cent) of stained sap will be permitted.

13. Round, sound knots, not larger than one (1) inch in diameter and not more than six (6), well scattered in any piece, will be permitted.

Long Leaf Yellow Pine and Fir.

14. Bright sap will not be considered a defect. A small amount (not more than ten [10] per cent) of stained sap will be permitted.

15. Round, sound knots not larger than one (1) inch in diameter and not more than six (6), well scattered in any piece, will be permitted.

16. Small pitch pockets, not over four (4) inches in length, will be permitted.

Inspection and Acceptance.

17. All over-shipments of any size of lumber, on any order, will be entirely at the risk of the shipper, and the purchaser will not be responsible for their safe keeping.

18. No allowance whatever will be made for material rejected. Freight charges on rejected lumber and 75 cents per thousand feet for handling culls at destination will be deducted from shipper's invoice. If shipping instructions are issued by shipper for rejected material, full freight charges will follow shipment to destination. A charge will be made for sawing material shipped in multiple lengths.

19. Inspection reports showing the result of inspection will be mailed to the shipper within two weeks after the unloading and inspection of the material, and rejected material will be held for thirty days from the date of the inspection report free of charge, during which time the shipper is expected to give disposition to the purchaser for such rejected material. Failure on the part of the shipper to give the purchaser such disposition will be considered as authority from the shipper to charge storage after the expiration of the thirty days mentioned, at the rate of 25 cents per thousand feet per day. Such charge will be deducted from the invoice of the shipper when final settlement is made for the lumber.

STANDARD WEIGHTS.
WEATHERPROOF WIRE.

Approximate Weights.

SOLID.

Size. B. & S. Gauge.	Double Braid. Lbs. per 1000 ft.	Double Braid. Lbs. per mile.	Triple Braid. Lbs. per 1000 ft.	Triple Braid. Lbs. per mile.
0000	723	3,817	767	4,050
000	587	3,098	629	3,320
00	467	2,467	502	2,650
0	377	1,989	407	2,150
1	294	1,553	316	1,670
2	239	1,264	260	1,370
3	185	977	199	1,050
4	151	795	164	865
5	122	646	135	710
6	100	529	112	590
8	66	349	75	395
9	54	283	62	325
10	46	241	53	280
12	30	158	35	185
14	20	107	25	130
16	16	83	20	105
18	12	64	16	85
20	9	48	12	65

WEATHERPROOF IRON WIRE.

Approximate Weights Per Mile.

Iron Wire Gauge.	Double Braid.	Triple Braid.
No. 4	860	940
6	665	740
8	470	525
9	400	450
10	350	400
12	225	260
14	145	175

WEATHERPROOF WIRE.

Approximate Weights.

STRANDED.

Capacity. Circular Mills.	Double Braid. Lbs. per 1000 ft.	Double Braid. Lbs. per mile.	Triple Braid. Lbs. per 1000 ft.	Triple Braid. Lbs. per mile.
2,000,000	6,690	35,323	7,008	37,000
1,750,000	5,894	31,119	6,193	32,700
1,500,000	5,098	26,915	5,380	28,400
1,250,000	4,264	22,516	4,508	23,800
1,000,000	3,456	18,246	3,674	19,400
900,000	3,127	16,513	3,332	17,600
800,000	2,799	14,779	2,992	15,800
750,000	2,635	13,913	2,822	14,900
700,000	2,471	13,045	2,650	14,000
600,000	2,093	11,052	2,235	11,800
500,000	1,765	9,318	1,894	10,000
450,000	1,601	8,452	1,724	9,100
400,000	1,436	7,584	1,553	8,200
350,000	1,248	6,589	1,345	7,100
300,000	1,083	5,721	1,174	6,200
250,000	907	4,788	985	5,200
Size-B. & S. Gauge.				
0000	745	3,935	800	4,220
000	604	3,190	653	3,450
00	482	2,544	522	2,760
0	388	2,051	424	2,240
1	303	1,599	328	1,735
2	246	1,301	270	1,425
3	190	1,004	206	1,090
4	155	820	170	900
5	126	668	140	740
6	103	544	115	610
8	68	359	78	410

FIRE AND WEATHER PROOF WIRE.
TRIPLE BRAID—BLACK OUTSIDE.

Capacity. Circular Mills.	Stranded. Lbs. per 1000 ft.	Stranded. Lbs. per mile.	Solid. Lbs. per 1000 ft.	Solid. Lbs. per mile.
1,000,000	3,860	20,400		
900,000	3,520	18,600		
800,000	3,180	16,800		
700,000	2,820	14,900		
600,000	2,350	12,400		
500,000	1,990	10,500		
450,000	1,820	9,600		
400,000	1,650	8,700		
350,000	1,440	7,600		
300,000	1,270	6,700		
250,000	1,060	5,600		
Size-B. & S. Gauge.				
0000	900	4,750	862	4,550
000	735	3,880	710	3,750
00	583	3,080	562	2,970
0	480	2,530	462	2,440
1	355	1,870	340	1,800
2	290	1,540	280	1,480
3	240	1,270	230	1,220
4	195	1,030	190	1,000
5	160	845	155	820
6	132	695	127	670
8	87	460	85	450
10			60	315
12			42	220
14			30	160
16			24	130
18			19	100

SLOW-BURNING WIRE.

Approximate Weights.

TRIPLE BRAID.

Capacity. Circular Mills.	Stranded. Lbs. per 1000 ft.	Stranded. Lbs. per mile.	Solid. Lbs. per 1000 ft.	Solid. Lbs. per mile.
1,000,000	3,980	21,000		
900,000	3,640	19,200		
800,000	3,280	17,300		
700,000	2,920	15,400		
600,000	2,460	13,000		
500,000	2,080	11,000		
450,000	1,900	10,000		
400,000	1,700	9,000		
350,000	1,500	7,900		
300,000	1,310	6,900		
250,000	1,120	5,900		
Size-B. & S. Gauge.				
0000	960	5,070	925	4,890
000	785	4,150	760	4,020
00	625	3,300	600	3,170
0	510	2,700	495	2,610
1	380	2,000	365	1,930
2	335	1,770	320	1,690
3	280	1,480	270	1,425
4	230	1,220	220	1,160
5	195	1,030	190	1,060
6	165	870	160	845
8	105	555	100	530
10			80	420
12			55	290
14			40	210
16			30	160
18			24	130

GENERAL INDEX

[Descriptions are indexed by page numbers and have the prefix p. Illustrations are indexed by figure numbers and have no prefix.]

A

B

C

D

E

N

O

P

T

U

V

W

Z